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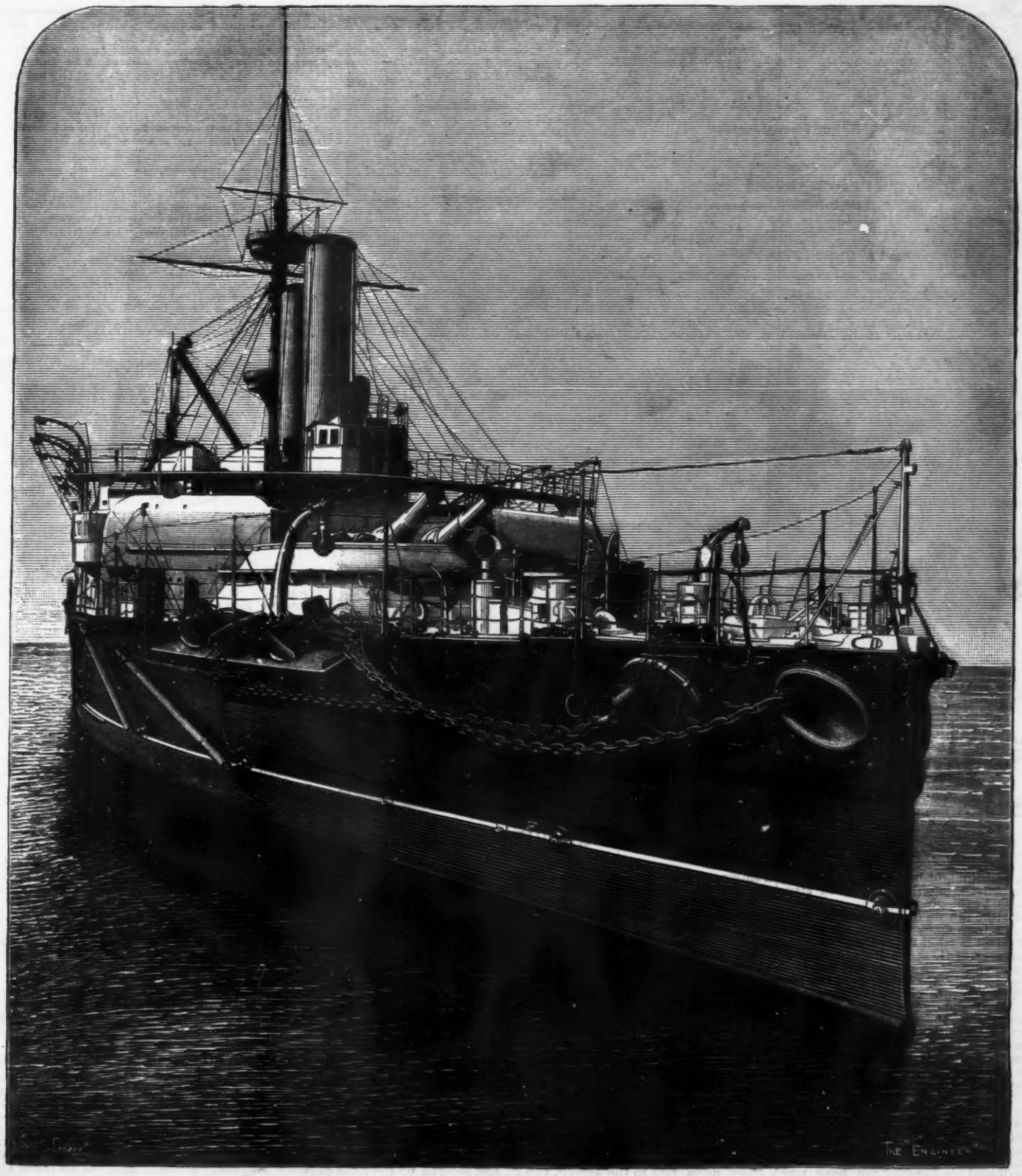
H. M. S. COLLINGWOOD.

THE drawings of H. M. S. Collingwood are from photographs by Messrs. Symonds & Co., of High Street, Portsmouth, and engraved in *The Engineer*, in which the following particulars are given.

The Collingwood was the earliest built example of the "Admiral" type of ironclads. She is an armored battle ship of the first class, and is almost identical in construction with the Rodney, Anson, Camperdown, Howe, and Benbow. She differs most materially, in disposition of armor and gun positions, from the Dreadnought and Inflexible classes which went before. The design of the Dreadnought, which was a modified form of the Fury, as originally planned by Sir E. J. Reed, was a battle ship with very low freeboard, having a broad belt of armor extending from stem to stern, and a long armored citadel with parabolic ends, each containing a turret rising above the belt. In the Inflexible the belt was discarded altogether, and only a short citadel, indeed almost square, was made amidships, which was plated with armor of enormous thickness, and contained all the heavy guns. The ends of the vessel being altogether unprotected, all her eggs, so to speak, were in one basket. The Colossus and Edinburgh were modifications of this class. The Collingwood was an entirely new departure in the way of ship building. In her arrangements were made to separate the gun positions, to place them within barbette towers at either end of the vessel, and to provide between them an extensive battery for a heavy auxiliary armament, quite a new feature in battle ships, but a vitally important one.

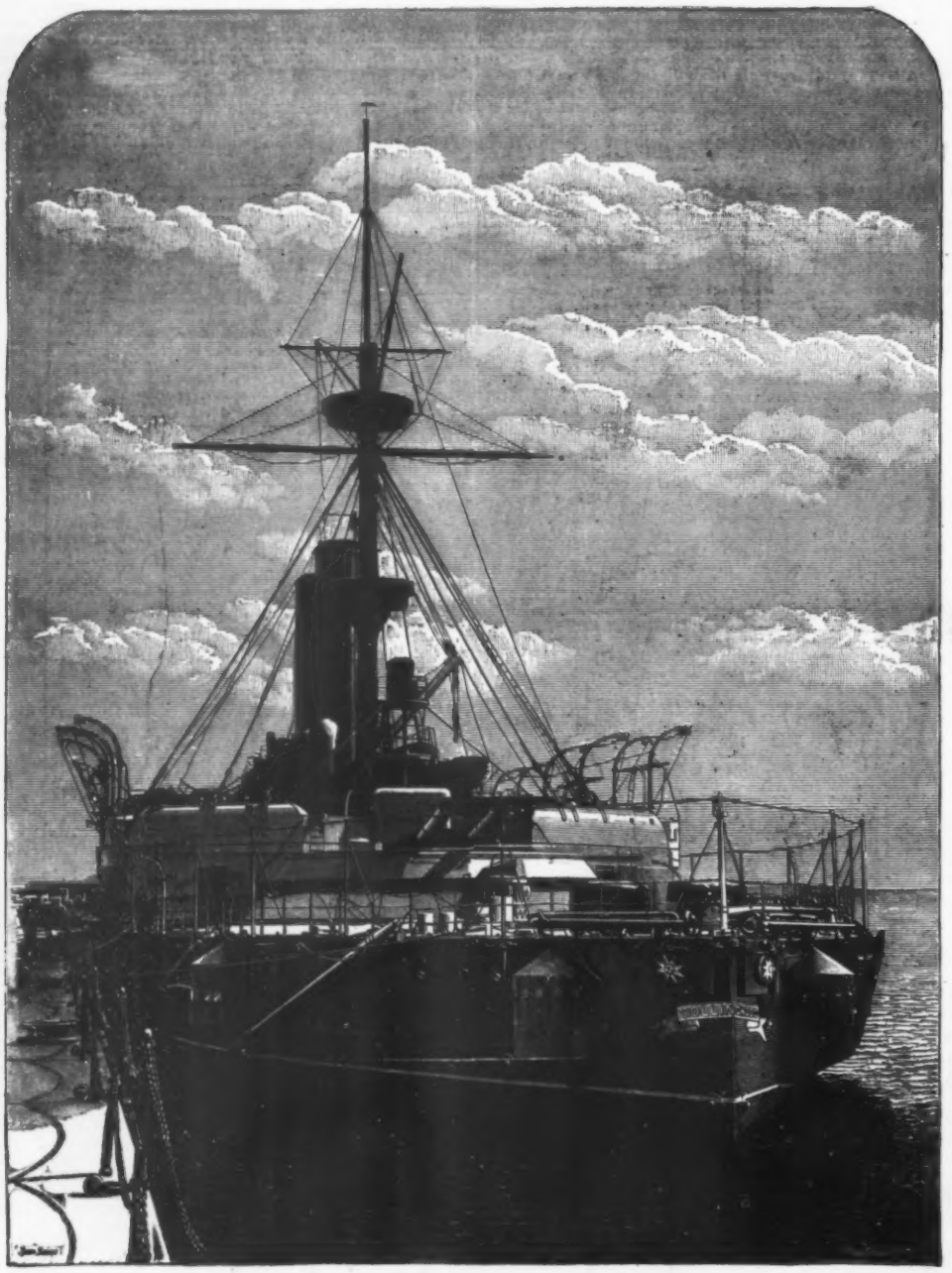
The barbette towers themselves, which contained the elevating and depressing gear, the loading and other apparatus, and the ammunition trunks leading to the magazines below the level of the water, were the only portions of the gun positions which it was thought necessary to plate with armor. At the water line, a narrow streak of armor ran from the base of one barbette to the base of the other, which was intended to prevent the penetration of projectiles into the boilers, engine rooms, and torpedo stores, in conjunction with the steel armored deck which ran from stem to stern. This design, which was most defective, has been im-



H. M. S. COLLINGWOOD—STARBOARD BOW.

proved on in a variety of ways, in the later examples of the Admiral class. Greater length has been given to the vessels, and consequently to the distance between the barbettes, resulting, of course, in a more extensive secondary battery. The armored belt has also been lengthened, and far heavier guns have been placed within the barbettes.

But, notwithstanding all these improvements, the class has been severely criticised, and at the meeting of naval architects in March last, grave defects were admitted to exist by the Admiralty representatives present, and it was pointed out that most of the modifications introduced into the designs of the director of naval constructions for our new battle ships were framed with a view of correcting those faults which were found to be inhesent in the Admiral type. These are an excessive shortness, giving rise to great unsteadiness in a heavy sea, and consequently loss of speed; the naked and defenseless condition of the auxiliary batteries, which are not protected by any armor plate, even of the thinnest description; the shortness and narrowness of the armored belt, that of the Collingwood being almost entirely submerged even in a calm sea; and the perilous condition of the heavy gun positions, which might be wrecked at once by a single projectile penetrating the unarmored structure beneath them, and exploding there.



H. M. S. COLLINGWOOD—STERN VIEW.

But although we have spoken of the Collingwood as wanting in so many respects, she is unquestionably a great advance upon the central citadel type. The barbettes are 140 ft. apart instead of being amidships. The guns are 22 ft. above the water. Naval officers will appreciate the advantage of the increased height at which the guns of the Collingwood are carried at sea. Command is everything under certain circumstances. Then the hydraulic loading machinery of each turret is completely independent of the other. When the whole of this delicate machinery was contained in one central citadel, penetration by a single shell might have been fatal to the working of both turrets. This might occur in the Inflexible. It cannot happen in the Collingwood. In the latter vessel great stress is laid upon the value of the protection afforded by coal bunkers filled. This appears to be justified by experience gained as the result of the experiments made with high explosives upon the hull of the Resistance last year. The shells which burst against the plates covering full coal bunkers did not have much effect upon the space between decks. The force appeared to expend itself among the coals.

We now give the various features, dimensions, etc., of the Collingwood. She is 325 ft. in length, with a beam of 68 ft. and mean draught 26 ft. 4 in., with a displacement of 9,500 tons. The Anson and Camperdown are 10,650 tons displacement each. Annexed we give a view of the ship's stern. The steam power of the Collingwood is, with natural draught, 7,000 horses; with forced draught, 9,500; nominal speed with natural draught, 15 knots; under forced draught, 16·5 knots; coal capacity, 900 tons. The length of the armored belt is 140 ft., as compared with 230 ft. in the Nile and Trafalgar and 250 ft. in the new designs. The armor is steel-faced compound, 18 in. on the belt, 16 in. on the bulkheads, and 14 in. on the barbettes. The total weight of armor and backing is 2,780 tons, as against 4,550 tons in the new designs, this fact alone showing the enormous strides which are being made in the proportion of armor to displacement. The armament of the Collingwood consists of four 45 ton steel breech-loading guns, 27 ft. 4 in. long, and gradually tapering from a diameter of 4 ft. 7 in. at the breech to 17 in. near the muzzle, which possesses what artillerists call a tulip or swell. The powder, which is stowed in the magazines in brass cylindrical cases, is brought to the foot of the magazine hoists, where it is taken from the case and passed through a metal shoot on to a lift, forming a second tier, below the shell, on the same lift, and then brought to the guns in the barbette through the thick armored tube or trunk before alluded to. Bollards rotated by hydraulic engines are employed for the purpose of lifting the powder and shell from the magazines and shell rooms, the burdens being afterward conveyed to the lifts by runners on overhead rails. The breech screw has to be released from the lands and the breech piece withdrawn and disposed of before the operation of loading can be begun. Then a semi-tube has to be inserted in the breech in order to prevent the projectiles injuring the threads of the screw, after which the shell and powder are introduced by repeated thrusts of the hammer, for the limited space within the annealed tube is such that it is necessary to push the projectile and the charge separately into the neck, as each is successively raised and secured at the proper elevation in a plane with the axis of the gun, which is depressed at the moment to an angle of 13 degrees below the horizontal. Then the entire performance is required to be reversed. The protecting tube is withdrawn, the breech piece is carried to the breech, run in, and secured by the sixth of a turn and locked, when the gun is ready to be forced up the inclined slides, laid, and discharged. The first operation of loading is the removal of the breech piece. This is a ponderous cylindrical steel casting about 3 ft. in length, and encircled by a succession of interrupted threads. The head is circular, and a little behind, at what may be called the shoulder, is the obturator, which is confined between two steel rings. The obturator is nothing more than a flexible packing of asbestos, which expands under the force of the powder, and by pressing against the surface of the chamber prevents the escape of the gases. The removal of the heavy breech piece is accomplished by an exceedingly ingenious application of hydraulic power. A tray mounted on a movable table is pushed laterally toward the axis of the gun, and in the course of its travel it collides against the lever actuating the breech screw, and forces it into a slot, whereby it is secured, whereupon a piston or extractor, situated at the rear in the same vertical plane as the gun, but below it, recoils, carrying the breech piece with it. The gun is now prepared for loading, and this is what takes place. The table carrying the screw retraces its lateral journey, closely followed by a second table, bearing the protecting tube already referred to. Then, by means of hand wheel and screw gearing, the tube is pushed forward into the breech over the threads, after which hydraulic power is applied to raise the projectile on the lift to the requisite height, when it is thrust into the gun by the rammer. On the rammer being withdrawn, the lift is elevated until the powder charge is brought into position, when a second thrust completes the loading.

The Collingwood has also a secondary armament of six 6 in. breech-loading rifled steel guns mounted on Vavasseur broadside carriages, and fifteen quick-firing guns of various classes. She has also eleven machine guns on the spar deck and in the tops, and in sponsons astern. There is also a deck beneath the auxiliary battery for torpedoes, the tubes for which work in gun metal ball and socket joints in the sides of the vessel, so as to be independent of the rolling of the ship or the wash of the waves against them. There are also torpedo ports ahead and astern. The funnels of the Collingwood are very capacious, and the heating experiment in the Colossus and Edinburgh under forced steam is thus obviated. On the whole, the Admiral type may be said to be a valuable one, but it is a pity that six of them should have been completed before exhaustive trials were made with the first specimen.

THE DYNAMITE GUNS OF THE VESUVIUS.

The final official tests of the dynamite guns forming the equipment of the fast cruiser Vesuvius took place last week, and have resulted satisfactorily. Commodore Goodrich, chairman of the trial board, reports that the tests were successful beyond anticipation. According to the account in the *Army and Navy Gazette* by one present—

One regulation shell was first fired from each gun to satisfy the requirement as to the range. These shells are about 7 feet long and 10 inches in diameter, hold 200 pounds of exposive gelatine, and weigh 483, 504, and 505 pounds respectively. All three were as steady in flight as a shell from a high-powered rifle. With a loss of pressure of 105 pounds in the firing reservoir, the first shell fell 32 yards beyond the mile buoy; with a loss of 80 pounds the second fell 250 yards over the line, and the third, with a loss of 73 pounds, ranged 100 yards beyond the buoy. The time of flight was between 11 and 12 seconds. This demonstrated conclusively that a loss of 70 pounds in the firing reservoir would satisfy the contract as to range.

It now remained to test the rapidity. The projectiles used in this test were not of the regulation pattern, but they weighed between twenty and fifty pounds more, being full caliber wood and iron dummies. It was not expected that these dummies would be steady in flight, as the center of gravity was not at the proper point to insure steadiness, but they answered all purposes in testing the operations of loading and proving the capacity of the air reservoirs.

Starting with a shell in the gun, five shots were fired from the gun in 4 minutes 23 seconds; the losses of pressure in the firing reservoir at the different discharges being 70 pounds, 74 pounds, 74 pounds, 76 pounds, and 78 pounds, respectively. The variation in the loss of pressure was due to the fact that the dummies vary several pounds in weight.

The middle gun was then tried, and starting with the gun unloaded, five shots were fired in 4 minutes 48 seconds. The losses of pressure in the firing reservoir were 105 pounds, 109 pounds, 114 pounds, 104 pounds, and 96 pounds respectively.

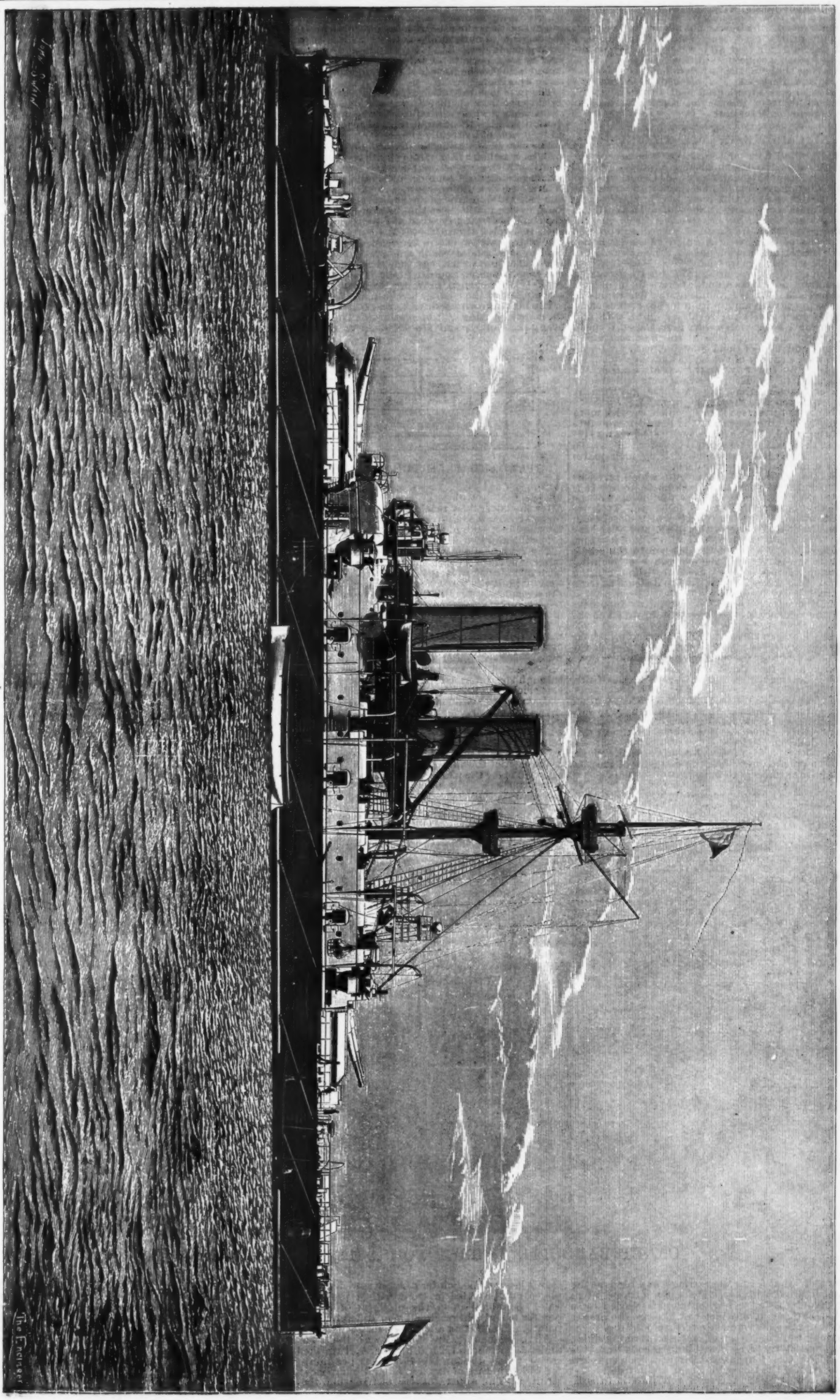
Five shells were next fired from the starboard gun in 6 minutes 58 seconds, the losses of pressure in the firing reservoir being 118 pounds, 112 pounds, 105 pounds, 120 pounds, and 118 pounds respectively. With one shell loaded in the port gun, therefore, the 15 shots were fired in 16 minutes 9 seconds, or, taking into consideration the time necessary to load all 15 shells—that is, starting with the three guns empty—the 15 shots were fired in 16 minutes 50 seconds.

When the test began, the air pressure in the storage reservoirs was 2,000 pounds per square inch. After the 15 shots had been fired the pressure was between 1,200 and 1,300 pounds per square inch, which was sufficient for at least ten shots more. Had the air pumps been kept running during the firing, five more shots could have been provided for. It is thus demonstrated that the Vesuvius can fire 30 shells—all she can carry—without stopping to fill the air reservoirs. This is double the capacity demanded by the contract, and the rapidity was nearly twice as great as was required.

A vessel that can deliver and explode three tons of high class dynamite a distance of a mile with any approach to accuracy is a most formidable agent for attack or defense.

TORPEDO BOATS CROSSING THE ATLANTIC.

The first four torpedo boats to cross the Atlantic left Plymouth for Bermuda on July 28, in convoy of H.M.S. Tyne, Commander W. T. Goodridge, R.N. The boats, Nos. 30, 31, 32, and 69, were first class Yarrow, 125 ft. long, manned by three officers and thirteen men, and were fitted out at Chatham and Portsmouth. The torpedo tubes, machine guns, and torpedoes had been previously removed and put on board the Tyne, which has been specially fitted for watering, coaling, and towing them if necessary. They were towed across the Bay of Biscay, and cast off near Cape Finis-



HER MAJESTY'S FIRST-CLASS BATTLE-SHIP, COLLINGWOOD, 9,500 TONS.

terre, afterward steaming by themselves, and being only taken in tow occasionally, while small defects were made good, which was not always an easy matter at night or in a heavy sea. Vigo and Madeira were visited *en route* for coal and water, and to rest the crews, sleep being sometimes difficult for them at sea. After leaving Madeira, the 30th parallel of latitude was followed, and Bermuda was reached on August 21. Fine weather was experienced nearly the whole way, except one night in the Bay of Biscay and for four days after leaving Madeira.

THE CANET BARBETTE TURRET.

ON the ground floor of the military palace of the exposition, upon the Esplanade des Invalides, may be seen a magnificent 12½ inch gun of the Canet type projecting from a huge cupola like those with which the Societe des Forges et Chantiers has just armed the three Japanese coastguards, Matsushima, Itsukushima, and Hashidate.

It was in 1887 that the Japanese government ordered the two first of these vessels, which gauge 4,200 tons, with the 460 ton artillery on board. The armament of each of these coast guards comprises: One 12½ inch Canet gun of 40 calibers, firing from a barbette turret, with ammunition for 60 rounds; twelve 4½ inch guns, with ammunition for 100 rounds each; five rapid-fire Hotchkiss guns, with ammunition for 400 rounds each; eleven 1½ inch Hotchkiss revolving guns, with ammunition for 1,500 rounds each; four Canet torpedo tubes, two of them fixed (one at the bow and one at the stern), and two of them movable, with broadside fire, and with a supply of twenty 15 foot torpedoes.

Let us say, by the way, that it was after a competition engaged in by Krupp, Armstrong, and several French contractors, that the Japanese government gave the preference to the Canet guns.

The barbette turret (see figure), which we wish more especially to describe at present, is placed in the fore part of the vessel. It is armored with steel plates 11¾ inches in thickness. The central tube for the passage of ammunition is itself armored with 9¾ inch plates from the armored to the upper deck.

The Canet 12½ inch, 40 caliber gun, which serves as the armament of this turret, weighs 66 tons. It is wholly of steel. The tube extends from one end of the piece to the other, and is 41 feet in length. It is reenforced with bands with clasps, which closely embrace the front and back of the piece, and with long hoops. The gun is not provided with trunnions, but, by means of hoops with notches, is set into the cradle of the carriage—a very efficacious means of securing an interdependence between the two without causing the stress to be exerted upon parts so delicate as trunnions are.

We shall speak neither of the obturating apparatus nor of the maneuvering of the breech, which is the same in all the Canet guns.

The 12½ inch gun throws a 990 lb. projectile, and the initial velocity reaches 2,300 feet per second. The charge is 616 lb., and the projectile is capable of piercing, at the mouth, a 3¼ foot thick iron plate and a 27 inch steel one. Its maximum range, at a 30° angle of fire, is 12 miles.

If we compare this piece of ordnance with any other existing gun of the same caliber, we shall have to concede that there is none more powerful. The tension of its trajectory secures for it, at the same time, great accuracy in firing.

Owing to the excellent arrangements of the carriage, it has been possible to reduce the diameter of the turret within the armoring to 24 feet.

The cradle that forms the carriage, and receives the gun and hydraulic brakes, slides upon a frame. This latter pivots around a horizontal axis carried by a movable platform upon which rest likewise the presses designed to raise the frame for vertical pointing.

Two longitudinal girders of cast steel forming slides, and connected by three cross braces, constitute the frame. The two journals, which rest upon supports forming part of the turret platform, are in front.

In the center of the turret, a well puts it in communication with the between-deck lower chambers, where the ammunition is stored. The entire mechanism of the lift is movable with the platform, and follows the carriage in horizontal pointing. This is an original arrangement devised by Mr. Canet, and one that, as may be seen, permits of bringing the projectile and charge right to the breech of the gun, whatever be the latter's position.

The tube forming this central well is held by a pivot fixed to the deck of the ship; at its lower part, it carries a mangle wheel which permits of a lateral pointing motion through the intermedium of a chain maneuvered by means of hydraulic presses.

The charge of powder is divided into two half-cartridges, which are taken from the magazines and carried, with the projectiles, beneath the platform by means of a carriage running upon rails. This carriage is let down by a pulley into a cage with three compartments, fixed upon the pivot and revolving with it. It is from this cradle that the ammunition is slid into the charge-carrying *revolver* the name of which indicates its analogy in form with the barrel of a revolver. The charge carrier enters the central tube, where it is held by steel guides which are inflected at the level of the platform in such a way that the carriage can reach the rear of the gun and rise to the level of the breech. A safety tappet then prevents the carrier from redescending until the loading has been effected.

The lift is maneuvered with two presses placed upon the upper flooring of the platform. The chains pass over guide pulleys and are attached to the carriage. After the latter has reached the rear of the gun, it is turned by hand so as to bring in succession, in front of the chamber, each of its compartments containing the projectile and two cartridges.

The ammunition is put in place with a hydraulic rammer of a special model. After the projectile has been introduced, a valve with a handle is acted upon so as to limit the travel for the successive ramming of the cartridges. In this way are avoided shocks and too strong compressions, which would break the grains of powder and deteriorate the charge.

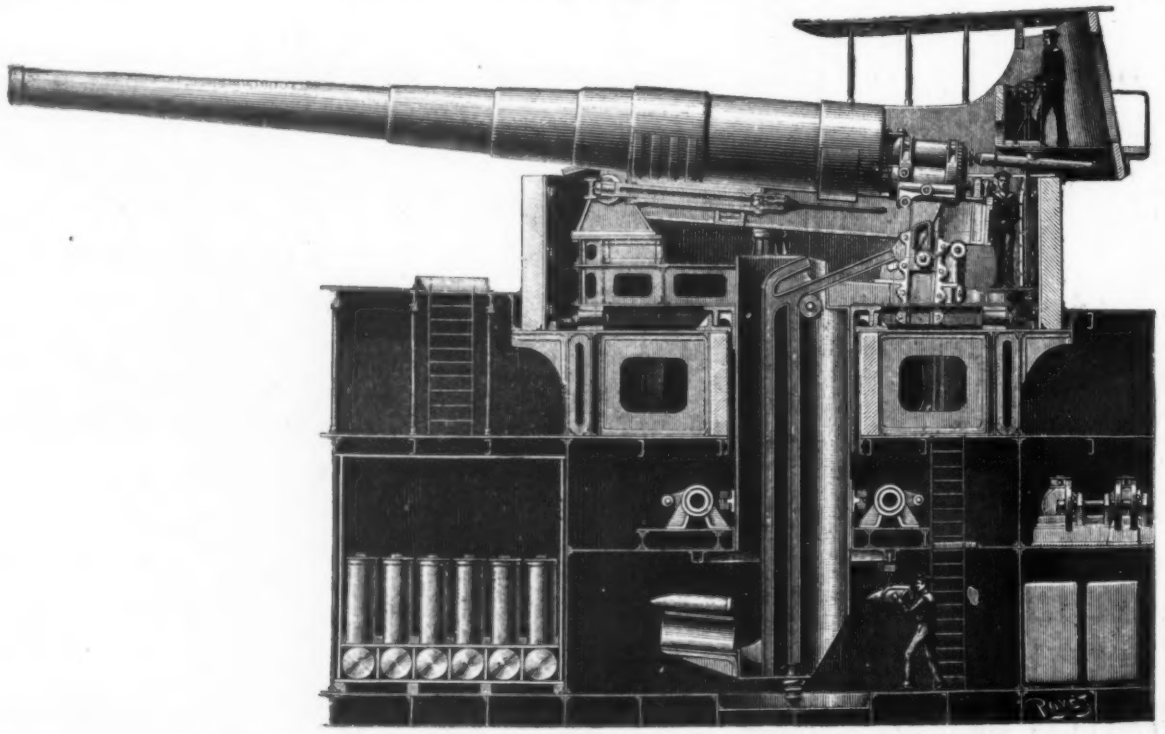
The plate iron work of the turret consists of the revolving platform, constituting a sort of drum formed of two floorings, connected by a hollow circular girder and by a series of radiating braces assembled with the upper part of the pivot tube. The entire turret rests, through the intermedium of a ring of rollers, upon a cast steel track fixed to the deck.

Upon the upper floor are fixed the supports of the covering, which consist of two longitudinal girders parallel with the frame girders, of a ring upon the circumference of the turret, and of radiating braces that connect the girders and ring. The covering itself is a 19½ inch thick steel plate, which protects the entire upper part of the turret, and is provided with a single embrasure for the passage of the gun. Finally, at the rear is located the pointer's box, armored with 4¼ inch plates, and provided in front with a protected sight-hole. Standing upon the platform of his box, the pointer has within reach all the different devices for pointing in elevation and direction.

All the maneuvers are effected with the aid of water under a pressure of 80 atmospheres, furnished by a steam pump discharging 75 gallons per minute, and for which, in case of damage, a hand pump can be substituted. The apparatus for distributing the water under pressure is placed upon the platform, as are also the levers that operate the double or single acting distributing slide valves, and permit of regulating the effect to be produced.

The maneuvering devices are within reach of the gunners, and there is consequently no order to be transmitted during the firing, each one knowing his own duty, and the principal functions devolving upon the pointer himself. Moreover, all parts of the turret are provided with safety apparatus that permit of performing a maneuver only at the desired moment, and when it can result in no accident. This is one of the most valuable features of this marine turret, while at the same time the loading by central tube assures of great ease in bringing it into play.

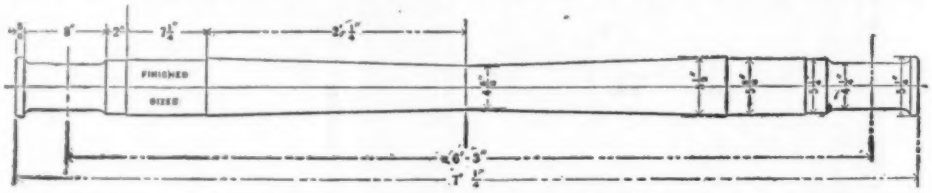
In most other systems, in fact, it is necessary to bring the turret to a definite position in order to effect the loading, on account of the eccentric position of the well in which the lift operates. The result of this is evidently a very great loss of time, which interferes with the rapidity of firing. In the turret just described, the gun remains, on the contrary, in its firing position, and the pointer has nothing else to think of, while the loading is being done, but the constant regulation of the pointing, so as to keep the object all the time at the end of his gun.—*Le Genie Civil.*



CANET BARBETTE TURRET FOR A 12½ INCH MARINE GUN.

THE STANDARD AXLE FOR 60,000 LB. CARS.

THE drawings presented herewith show the dimensions of the standard axle which the Master Car Builders' Association has adopted by its recent letter ballot.—*Railroad Gazette.*



STANDARD AXLE FOR 60,000 LB. CARS—ADOPTED BY THE MASTER CAR BUILDERS' ASSOCIATION, SEPTEMBER, 1889.

ENGLISH AND AMERICAN RAILWAYS COMPARED.*

By EDWARD BATES DORSEY, Mem. Am. Soc. C.E., Mem. Am. Inst. M.E.

SOME years ago the author, who was then in England, thought that he would confer a favor upon the American engineers by preparing a paper showing them the advantages of constructing their railways in a thorough manner, as is the practice in the United Kingdom. He expected to show that it would be more profitable in the end to construct the roads thoroughly at first, as the saving in operating expenses would more than make up the additional interest on the greater cost. This paper was announced to be read before the American Society of Civil Engineers in September, 1884. It required a long time to collect the necessary data, however, and when he came to analyze and compare these with the American, he was astonished to find that the cheaply constructed American railways were being operated at much less cost than the thoroughly built English railways. This so astonished him that he thought there must be some error in his data, and that it would be prudent to postpone reading the paper until he could again visit England and check his figures, which he did, and found that his first date were correct. The paper was finally read before the American Society of Civil Engineers, on June 24, 1885.

* A paper read before the British Association, Section G, Newcastle, 1889.

The American and English railway engineers have worked from entirely different standpoints. The latter had plenty of money at his command, and therefore he built his road thoroughly at first, with easy grades and curves, while the former was always short of money, and constructed his work as cheaply as possible, with sharp curves and steep grades which compelled him to get rolling stock adapted to it. This caused the general adoption of the bogie truck, as it runs smoothly round sharp curves, even of one chain radius, with much less friction and wear and tear than the English rolling stock with its long rigid wheel base. As a matter of history, one of the first locomotives used in the United States was built by Stephenson, with the usual long rigid wheel base, and could not be made to keep on the poor and rough American tracks with their sharp curves, but after a bogie truck was put under it, it did good service. The steep grades on the American roads have forced their engineers to diminish as much as possible the proportion of dead weight to paying load, which accounts for the great difference in tare weight to carrying capacity found between the two systems. There are no returns given by English as by American railways, showing the tonnage or passenger mileage, or the average charge per ton or passenger per mile. After very careful investigation, however, the author was convinced that the average freight charge upon English railways was over 1¼ pence per mile per ton of 2,240 lb., but, in order to be conservative, he has estimated the average charge to be one penny, with no allowance for the difference between the English ton of 2,240 lb. and the American ton of 2,000 lb., upon which all American tonnage reports are based. The ton mileage was found by multiplying the reported receipts in pounds sterling by 240. The author estimated that upon the English railways the average charge per passenger per mile, first, second, and third class, was 1½d. The passenger mileage was found by multiplying the reported receipts in pounds sterling by 206.

Since these estimates were made the author has continued his investigations, which confirms his original conclusions. They are also confirmed regarding freight rates by the recent publication of the maximum charges and rates by the railways. The English railways give no reports by which the cost of the freight can be separated from passenger traffic. By comparing all the data available, it appears that the cost of transporting one passenger or one ton one mile is about the same on the principal English railways. This is shown by analyzing and comparing the reports of the roads, which have very different percentages of freight and passenger traffic. The American roads keep very accurate and detailed accounts of the ton and passenger mileage, the average receipts from each ton or passenger transported one mile, and the average cost of transportation of each.

In table No. 1 the London and Northwestern, Great Northern, Midland, Great Western, and Great Eastern railways of England are compared with the Pennsylvania railroad and the Knoxville branch of the Louisville and Nashville system. These two last named roads represent the extreme types of American railway construction, the first being one of the best, and the last one of the most cheaply constructed roads in America. Both are built through an undulating and, in places, very rough country, the Pennsylvania crossing a summit 2,154 feet above tide water, its initial point. All these figures, except the tonnage, mileage, and the charge per ton per mile on the English railways, are from the official reports of the respective companies for the year 1888. The author intended to include in the comparisons in Table No. 1 the Northeastern railway, but could not spare the necessary time to look into its practical working previous to this meeting. The cost per mile of the Pennsylvania railroad division as given in table No. 1. is exclusive of equipment.

Table No. 1 shows plainly the comparative operations of the railways compared, which can be taken as types of their respective classes, and should be studied closely by all interested in railway matters, either as shareholder or shipper. This table shows the fallacy of the usual argument made use of by the friends of the English system, that the high charges on the English railways are caused by the short haulage of their freight and the high terminal charges. In this they are undoubtedly at a great disadvantage when compared to the American railways. The exact amount of this it is impossible to ascertain from the data heretofore given; but in order to be perfectly sure that enough is deducted in paragraph ten of table 1, all traffic expenses—coaching and merchandise—amounting to 36 per cent. of the total operating expenditure of the London and Northwestern railway, are deducted, and deducting nothing from the Pennsylvania railroad, the cost of transporting one ton one mile is still greater on the English road, the percentage being 62 per cent. against it. By deducting all traffic expenses—coaching and merchandise—from both roads, which is the most correct way of calculating, the difference between the cost on the two roads is much larger, being 149 per cent. against the London and Northwestern.

The reported share and bonded capital of American railways do not represent their cost. In most of the roads constructed during the last twenty-five years, representing over sixty per cent. of the total American railway mileage, all the share capital, and in some instances also a large part of the bonds, have gone to the promoters or contractors as their profits. The average book cost per mile of the American roads is $60,026, the actual average cost is probably under $35,000 or £7,000. In nearly all of the States comprising the American union there is a free railway law. Under this law any three artisans can get a charter to build and run a railway to and from any points within that particular State, except through chartered cities. This charter can be obtained in a few hours, and at a nominal cost. In some States the cost is only 50s., giving the same powers as are conferred by an English act of Parliament, and this without any restrictions or conditions. This facility for constructing railways has resulted in the building of too many roads from the shareholders' standpoint, causing too much competition, and is undoubtedly bad for the railways. But it is very good for the farmer, manufacturer, miner, etc., as it assures them that cheap freight which has made the United States what it is now. It prevents monopoly or excessive charges, for as soon as any road shows good earnings, a competing line is made to get its share of the business. This sharp competition has forced the railway management to economize wherever possible, to adopt all improvements, etc.; in fact, it has developed the present American railway practice.

In order to show plainly the comparative workings of English and American railway practice, the author reproduces the table No. II., compiled by him, and his remarks upon it taken from page 112 of his book entitled "English and American Railroads Compared." The average cost per mile of the Pennsylvania railroad, exclusive of equipment, is $64,091=£13,215 (£1=$4.85); and that of the London and Northwestern is £52,573, or about four times greater. Although the Pennsylvania railroad is considered a trunk or through line, yet in 1888 only 6·48 per cent. of its tonnage was through freight, the local freight being 93·52 per cent. of the whole tonnage. As is shown in table I., 77 per cent. of its traffic is eastward and only 23 per cent. westward.

In table No. II., the total cost of operating expenses, the Pennsylvania railroad has the advantage in having a longer haul. This, however, does not affect the three other items of cost. In paragraph ten of table 1., it is shown that after deducting all traffic charges on the London and Northwestern railway, and nothing on the Pennsylvania railroad, the average cost of transporting freight is still much higher on the English roads. It is safe to say that if the American railways should now advance and maintain their freight charges up to the high English rates, a very large and thriving portion of the United States would have to be practically abandoned, as but little could be produced that could stand the high freight charges. This section has now a population of over 20,000,000, and produces over one-half of the food products exported from the United States, which would with the English high rates turn it into a grazing country and drive away its population. Its present prosperous condition is owing entirely to cheap railways and cheap freight rates. Wheat raised in the Western or central portion of the United States is transported over 1,500 miles by railway to the shipping port, and thence over 3,000 miles by vessel, and is sold in England in direct competition with the wheat raised by the English farmer. Could this be done if the American railways charged as much as the English? Would not the railways in that case be obliged to take the wheat for their pay?

In the United States all railway rolling stock is built with the bogie trucks, experience having shown that they run easier, especially on curves, the wear and tear on the rails is less, and there is much less jar or jolt to the load than with the English type of wagons. Experience has also shown that economy in transportation increases with the increased weight of paying freight in each car and train load and decrease of tare, consequently the paying freight load of freight cars had increased from ten to thirty tons. In the United States railway practice it has been found that the tubular iron car is the best design in use, combining, as it does, a minimum of dead weight and wear and tear with a maximum carrying capacity and great durability. The open cars weigh eight and one-third tons, and carry a paying load of thirty tons. This style of car has recently been introduced into England by Sir James Ramsden, the manager of the Furness railway, and has shown its marked advantages over the present type of rolling stock.

If the American railway system is not the best, why did the engineers of the Canadian railways adopt it? In some cases they changed the English rolling stock into the American type, and this when the roads were built with English capital. The fact is they were obliged to make the change in order to compete with their American rivals. It does seem very strange that the English railways, which are the best constructed in the world, should be operated so much more expensively than the American roads, which are generally so inferiorly built. All the trunk lines in the United States would soon be bankrupt if they only received their present freight charge and were operated as expensively as the English railways are.

The following are the reasons that have been given by the English railway officials why the American practice cannot be adopted here or why the English railway charges are so much higher. The author gives his answer to each objection:

1. The impossibility of using on the short English turntables the long American freight car. Answer: From the author's investigation he is safe in saying that on the average less than 5 per cent. of the wagons now used in England go on the turntable; moreover,

TABLE NO. II.—*London and North-Western Railway, of England, Compared with the Pennsylvania Railroad Division of the Pennsylvania Railroad, of the United States.*

	London and North-Western.		Pennsylvania Railroad Division.	
	1884.	1885.	1884.	1885.
Total length of line operated .. .. .. miles	1,811	1,828	1,471	1,513
Single track .. .. miles	291	289	1,062	1,109
Double track .. .. miles	1,206	1,280	302	304
Three track .. .. miles	28	29	76	77
Four track .. .. .. miles	126	130	31	32
Percentage of single track to total length of line operated	22	22	72	73
Aggregate daily trains over entire line	68	66	45	46
Average annual train mileage per mile of line operated ..	21,086	20,908	14,135	14,510
Average annual mileage over each mile of line operated:				
Passenger	414,361	404,079	165 310	182,256
Ton	809,153	788,725	2,095,513	2,186,078
Passenger and ton	1,223,514	1,192,804	2,260,813	2,368,334
Average annual mileage over each mile of single track, all being reduced to single track:				
Passenger	213,730	207,721	120,564	133,396
Ton	417,367	405,440	1,527,502	1,600,082
Passenger and ton	631,097	613,161	1,648,066	1,733,428
Average load of freight trains .. ..tons	78	78	205	210
Average load of passenger trains .. .. passengers	93	87	42	45
Average load of all trains, tons and passengers	88	83	160	167
Average cost of transporting one ton or one passenger one mile.	Cents.		Cents.	
	1884.	1885.	1884.	1885.
Maintenance of way	·209	·205	·103	·080
Repairs and renewals of locomotives	·062	·060	·044	·027
Total cost of motive power ..	·271	·270	·148	·133
Total operating expenses ..	1·130	1·110	·580	·410

Sidings are not included in the above mileage.

This table shows that the Pennsylvania railroad on the Pennsylvania railroad division does annually twice the average amount of passenger and freight traffic on each mile of road operated, and nearly three times the traffic over each mile of single line.

TABLE NO. I.—*English and American Railroads Compared in Operating Expenses.*

1888.
£1 = $4·80. 1d. = 2 cents.
All figures representing cost are in Pence, except the average cost per mile of railway operated, which is in Pounds.
Calculated £1 = $4·85.

	Pennsylvania railroad division.	Knoxville branch, Louisville and Nashville system.	London and North-Western.	Percentage against L. and N.-W. and in favour.		Great Northern.	Percentage against Great Northern and in favour.		Midland.	Percentage against Midland and in favour.		Great Western.	Percentage against Great Western and in favour.		Great Eastern.	Percentage against Great Eastern and in favour.	
				Pennsylvan'a division	Knoxville branch.		Pennsylvan'a division	Knoxville branch.		Pennsylvan'a division	Knoxville branch.		Pennsylvan'a division	Knoxville branch.		Pennsylvan'a division	Knoxville branch.
Average cost per mile of railway operated, in Pounds	*£13,215	£8,090	£52,647	—	—	£39,400	—	—	£53,466	—	—	£29,046	—	—	£40,714	—	—
1. Percentage of total tonnage mileage transported East ..	77	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2. Percentage of total tonnage mileage transported West ..	23	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3. Average tons in loads of freight trains	214	154	79	171	96	89	263	161	61	251	152	64	234	140	62	245	149
4. Average charge for transporting one ton one mile	·317	·405	1·00	215	120	1·00	215	120	1·00	215	120	1·00	215	120	1·00	215	120
5. Percentage of operating expenses to earnings	64	58	52	—	—	56	—	—	52	—	—	49	—	—	54	—	—
6. Percentage of operating expenses to earnings on the Pennsylvania Railroad Division, provided it charged the same rates for freight as are charged on the English railways, viz., 1d. = 2 cents per ton per mile	—	—	20	160	—	20	160	—	20	160	—	20	160	—	20	160	—
7. Percentage of increased earnings that the Pennsylvania Railroad Division would receive if it worked with their present operating expense and received the same freight rates (1d. per ton per mile) as the English railways now receive	—	—	615	—	—	615	—	—	615	—	—	615	—	—	615	—	—
8. Percentage of "traffic expenses—coaching and merchandise" to total operating expenses	35	32	36	—	—	34	—	—	34	—	—	29	—	—	31	—	—
9. Average cost of transporting one ton one mile. The cost for the English railways is found by multiplying the estimated charge of 1d per ton per mile by the percentage of operating expenses to the gross earnings, as per paragraph 5 above	·206	·252	·52	152	106	·56	179	122	·52	152	106	·49	139	94	·54	102	110
10. Average cost of transporting one ton one mile, deducting on the English railways all "traffic expenses—coaching and merchandise," and deducting nothing from the total operating expenses of the American railroads ..	·206	·252	·333	62	32	·370	·80	47	·343	66	36	·348	68	38	·373	81	48
11. Average cost of transporting one ton one mile, deducting all "traffic expenses—coaching and merchandise" on all roads	·134	·171	·333	149	94	·370	176	116	·343	156	100	·348	160	103	·373	178	118
12. Average cost of train mile—freight and passenger	42·06	35·50	83·26	—	—	27·51	—	—	27·40	—	—	28·77	—	—	27·76	—	—
13. Equated cost of train mile on the English railways, provided they transported their present train loads at the same cost per ton per mile as is done by the American railroads, to which they are compared	—	—	Cost .. 15·52 Per cent. 114		18·21 83	Cost .. 11·13 Per cent. 147		13·60 102	Cost .. 12·00 Per cent. 128		14·06 95	Cost .. 12·58 Per cent. 129		14·75 95	Cost .. 12·19 Per cent. 128		14·29 94

* Exclusive of Equipment.

some of the present small wagons could be retained for their turntable traffic. With properly constructed sidings, freight on the long bogie-truck car can be handled much quicker and cheaper than on the short wagon by the use of turntables. In the American practice, where is found the cheapest freight charges in the world, turntables are never used except for the purpose of turning locomotives, so that their bogie truck will go ahead to pilot the driving wheels round the curves.

2. The present plan of the English stations and sidings would have to be changed, to accommodate the long freight car. Answer: This would apply only to stations where turntables are used. A very important item in favor of the long and high-capacity car is that it only requires about half the station or siding room that the short English wagon does in order to handle the same quantity of freight. The standard American car is 34 feet long, and loads 30 tons; the present English wagon is 18 feet long, and only loads 7 to 10 tons.

3. The adoption of the American practice would mean a radical change, and would be virtually a reconstruction of the English rolling stock. Answer: This is to some extent true; but the transformation must of necessity be gradual, as by building seventy-five cars per day for 300 days per year, it would require twenty-five years to replace the present rolling stock. All the new rolling stock required could be made on the American principle, and as the present wagons come into the shop for extensive repairs, the wheels and axles of two of them, if in good condition, could be placed in the bogie trucks of the new car. All the principal American railways have found it advantageous to change and remodel their practice entirely in the last fifteen years; during which time the carrying capacity of the freight cars has been increased from 10 to 30 tons paying load, decreasing the proportion of tare weight; and the weight of locomotives has been increased from 30 to 60 tons, and the roadbed, superstructure, bridges, etc., have all been strengthened to carry their increased load safeiy.

4. It is frequently stated that it is impossible to use the large freight cars in England, owing to the great number of small shippers who require a car exclusively for their small shipments, even when the quantity is much less than a car load. Answer: This difficulty is easily overcome on the American roads by running a special train that distributes and collects all local freight when in small quantities—the same as milk trains now do on some of the English railways. Moreover, 72 per cent. of the total tonnage of the freights handled in the United Kingdom are minerals—surely they can be sent in full car loads, and the large cars could be used for this traffic if for no other.

5. The freight traffic being largely in one direction, compels the movement in return of many empty wagons. Answer: 77 per cent. of the total tonnage mileage of the Pennsylvania railroad is eastward and only 23 per cent. westward. It is doubtful if any railway in England that is not exclusively a mineral road can show so great a disproportion.

6. The heavy terminal charges and expenses upon English railways compel high rates for freight. Answer: All the station and service terminals charges, as given in the "Maximum rates and charges," can be deducted, still leaving a very high freight charge; or by deducting from the English cost all traffic charges—coaching and merchandise—amounting to 36 per cent. of the whole operating expenses, and deducting nothing from the Pennsylvania railroad, the English charge is still 62 per cent. greater than the American.

7. Many persons think that the English railways are operated cheaper than the American, because the cost of the train mile is about 30 per cent. less than it is on the American roads. Answer: When proper allowance is made for the difference in the train load, the American road does the same work at much less cost. For example, the average freight train on the Pennsylvania railroad transports 214 paying tons at a cost of 42·06d., while on the London and Northwestern the average cost is 33·26d., only transporting 79 tons. Paragraph 13, table No. 1, shows this very plainly. By making proper allowance for the load of trains, the percentage against the London and Northwestern is 114 per cent.

8. It is said that the English railways are operated cheaper than the American, because their operating expenses, when compared to the total earnings, are much less. Answer: This is very misleading. Paragraphs 6 and 7, of table No. 1, show that, if proper allowance be made for the difference in the charge for transporting one ton one mile, the advantage is greatly in favor of the American roads. On the Pennsylvania railroad it would be only 20 per cent. of the whole operating expenses, and 160 per cent. against the London and Northwestern railway.

The author has professionally examined a new railway route from a large interior manufacturing town and district of England to good docks on the coast, and finds that this road would not cost to exceed £10,000 per mile, allowing liberally for land damages, etc., and could pay good dividends by transporting freight at less than half the present charges. This road would be built entirely for freight, the present passenger accommodation being considered ample and satisfactory. The author is convinced that a great many cheap freight railways could be constructed in England that would pay good dividends on the investment, and transport freight at half the present charges. This alone would double the value of farms, and would be a boon to the miner and manufacturer in their present close competition with foreign countries.

The preceding tables show that on the English railways, which have cost from four to six times more to construct than the American roads, the cost for transporting freight is more than double the American cost, whereas it should be less, or why make the increased outlay for superior construction? The author thinks that the great difference in favor of American railways in the cost of operating expenses is owing principally to the following reasons: First, the trains on the American railways carry much larger loads than those on the English roads; second, the universal use on the American railways of rolling stock with bogie trucks, which run with much less friction and wear and tear than the English rolling stock with its long rigid wheel base; third, the general use on the American railways of freight cars or wagons carrying a greater percentage of paying load to dead weight than those used on the English railways; fourth, the lower speed at which the American goods trains run; fifth, the use on the American railways of heavier locomotives, which haul heavier loads than can be done by the lighter ones used on the English railways; sixth, the use of locomotives on the American railways with outside cylinders and connections, which can be more cheaply and easily repaired than those with inside cylinders used on the English railways; seventh, the use on the American railways of collecting and distributing goods trains, which load and unload at the station goods in less than car load quantities, thus avoiding having wagons only partially loaded, as is the custom on the English railways. In this the Americans apply to their goods trains the same principle that the English railway managers now apply to their milk trains.

The present freight charge on pig iron from Stoke-on-Trent to Liverpool is 5s. 5d. per ton—distance, fifty-five miles. From Birmingham, Alabama, to Pensacola—both in the United States—the freight charge is $1.40 = 5s. 7½d. (£1 = $4.80)—distance 280 miles—the freight being about the same for five times the distance; this is a practical illustration of the difference between English and American railway practice, and its effect upon the trade of the country. The Birmingham district in the United States is only three or four years old; it will produce this year over 800,000 tons of pig iron. With railway freights as high as they are in England the iron could not be profitably made, and the whole district would be depopulated and abandoned. These are stern, real facts, and cannot be put aside by saying that they are estimates or theoretical possibilities.

The preceding remarks and opinions are not founded on theory or some new invention, but are founded upon actual workings of many years of all the American and Canadian railways, embracing over 170,000 miles of operated lines, with over 1,100,000 cars and carriages, constructed and run on the principle advocated in this paper. This can no longer be considered an experimental test. What is done in America on such very large scale could surely be done here. The author has spent much of his time in England, and he hopes to spend much more. He is anxious to see England continue her prosperous career, but as an extensive and observing traveler, he is sorry to see that she has not kept up in the race for commercial supremacy in her methods of inland transportation. When the present railways were constructed, England had comparatively no commercial rivals. Now strong, and in some cases successful, ones have sprung up on all sides. If any one, then, had told the English farmer that wheat raised in the interior of North America, Australia, or India would compete successfully in the English market with the wheat raised by the farmers of the United Kingdom, the person making the prediction would have been thought crazy.

But suppose he had gone further, and predicted that the fresh beef and mutton raised and consumed in England would find a successful rival in that raised in the Rocky Mountains of America, or on the pampas of South America, or in the interior of Australia, the English farmer would have thought this prediction too absurd to answer or notice. Both of these predictions have now been realized, and the farmer finds that, handicapped as he is by high charges for transportation to market, he cannot compete; consequently his market his lost, and his lands have depreciated greatly in value. The remedy is simple.

Let the railways give the English farmer the same rates to market that his foreign competitor pays, which can be done by adopting modern rolling stock and railway practice; or construct cheap railways on the American plan that will give cheap transportation. When this is done the English farming lands will greatly increase in value, manufacturers and miners will increase their work, and be placed on a favorable footing to compete with other countries in the markets of the world.

After six years' careful study of the English railways the author thinks that it is possible, by adopting the practice that has answered very well in other places, to make very large reductions in the cost of railway transportation, and that without diminishing the present dividends.

[Continued from SUPPLEMENT, No. 722, page 11534.]

THE CHANNEL BRIDGE—PRELIMINARY DESIGNS.*

By Messrs. SCHNEIDER & CO., Creusot Iron Works, and H. HERSENT.

PART II.

FOUNDATIONS—H. HERSENT'S PRELIMINARY PROJECT.

III.—DETAILED DESCRIPTION OF THE FOUNDATION WORKS.

Section 1. *The situation and dimensions of the brickwork supporting columns.*—The ground affording sufficient resistance to safely support the piers when loaded, the surface of the bases has been so calculated that the foundation should not have a greater load than about 10 kilos to the square centimeter. With regard to the pillars sunk at 55 m. under the low water level, the dimensions, the calculations of the masonry sections, and the corresponding weights per centimeter are summed up in the following table:

Length at base	57·00 m.
" at low water level	47·50 m.
" above the cornice	42·00
Width at base	32·00
" at low water level	22·50
" above the cornice	17 90
Surface at base	1,604 m.²
" at low water level	960 m.²
" above the cornice	651 m.²
Volume—exterior	86,000 m.³
" of the recess	28,000 m.³
" of the masonry	57,200 m.³
Loads to be supported per square centimeter at base on ground	9·80
Loads at low water—on the masonry	5·75
" at base of columns—on hewn granite	8·20

These resistances offer every appearance of safety, alike as regards the ground, the ordinary masonry, the body of the pillar, and the granite blocks supporting the metal columns. The base appears to be sufficient to resist the different transverse and longitudinal stresses—of which wind is the most important cause—that may tend to overturn the pillars. The length of the spans supported by the columns is 400 meters. The surface exposed to the action of the wind on this distance is about 7,590 square meters. The surface exposed to the action of the wind on the metal columns, 622 square meters. The surface exposed on the 20 m. sub-basement, 370 square meters. The surface exposed on the lower part of the piers, 1,570 square meters. Assuming that the force of the wind and the strength of the pressure exercised by the currents attain altogether 270 kilos. per square meter, the stresses produced upon each of these surfaces will be as follows:

$$7{\cdot}590\ \text{m.}^2 \times 270\ \text{k.} = 2{,}049.300\ \text{ks.}$$
$$622\ \text{m.}^2 \times 270\ \text{k.} = 167{,}940\ \text{ks.}$$
$$370\ \text{m.}^2 \times 270\ \text{k.} = 99.900\ \text{ks.}$$
$$1{\cdot}570\ \text{m.}^2 \times 270\ \text{k.} = 423{,}900\ \text{ks.}$$

And the moment of overturn will be—

$$2{,}049.300\ \text{k.} \times 137{\cdot}1\ \text{m.} = 280{,}959{,}030\ \text{ks.}$$
$$167{,}940\ \text{k.} \times 95{\cdot}4\ \text{m.} = 16{,}021{,}476\ \text{ks.}$$
$$99{,}900\ \text{k.} \times 66\ \text{m.} = 6{,}593{,}400\ \text{ks.}$$
$$423{,}900\ \text{k.} \times 28\ \text{m.} = 11{,}869{,}200\ \text{ks.}$$

Total moment of overturn at the base of the piers...315,443,106

One length of span of 400 m. weighs	1,164,000 ks.
Two metal columns	2,010,000 ks.
One masonry pier	148.675,000 ks.
Total weight	157,849,000

The points of the emergence of the resultant, x, from the center of the pillar is

$$x = \frac{315{,}443{,}106}{157{,}849{,}000} = 1{\cdot}99\ \text{m.}$$

The surface of a column is 1,604 square meters. The moment of inertia of s in relation to the small axis of the column is 355,346.

$$\text{Hence } r^2 = \frac{355{,}346}{1{,}604} = 221{\cdot}5\ \text{m.}$$

One-half length n of the columns is 28·5 m.

$$\text{Hence } \frac{r^2}{u} = d = \frac{221{\cdot}5}{28{\cdot}5} = 777\ \text{m.}$$

The coefficient of stability, that is, the ratio of the amount of overturn at the base of the piers, as compared with the momentum that would be produced by a compression equal to zero upon the extreme edge of the leeway, will be

$$\frac{d}{x} = \frac{7{\cdot}77}{1{\cdot}99} = 3{\cdot}90.$$

Each pier is to consist of a block of good material, in which two recesses or walls are cut out in order to diminish their weight at the base. The particular portion upon which the metal columns rest will be the same in all pillars, but the lower portion will increase in surface in proportion to the height to which the structure is to be immersed in water. The external walls will have a batter of 0·10 per meter, and the lower part, which will be taken up by a metal caisson, will project over the external face of the wall as shown in the plan.

Caisson.—The metal caisson of each pillar will correspond in external shape and dimensions to the contemplated depth of the foundations. It will consist of two distinct parts. The lower part will be 2 m. high and open at the base, while the upper one, the exterior of which will surround the masonry of the body of the pier, will form one single chamber, extending over the whole surface of the caisson.

Special frames and cross pieces will serve to maintain the sheet iron casings in position and in a state of rigidity. The lower portion, intended for the use of compressed air, and for fixing the structure to the ground, will consist of an external metallic casing limiting the periphery, and of vertical walls, dividing the horizontal surface into compartments of from 50 to 60 square meters each—these compartments, capable of being used and expanded either separately or together, each provided with compressed air, and intended for clearing the ground of foreign matter, or simply to level it, and to effect the final filling at the junction of the structure with the ground.

Each of these compartments of the base will be provided with air sluices arranged at the bottom, and with special devices for facilitating access and inspection, for removing excavated matter, and for filling up the excavations with concrete from outside.

The first piers on each shore may be constructed without necessitating any alteration in the means ordinarily employed for this kind of structure. The experience acquired in sinking these first piers will thus enable improved methods to be adopted for the thorough clearance of the soil, the filling of the compartments, and, in short, the completion of the whole base in the case of depths exceeding from 20 m. to 25 m. below the surface of the water.

In exceptional cases they reached 30 m. and above 35 m., but at such depths accidents have sometimes occurred, which appear to have been the result of excessive fatigue on the part of the men employed, and of the want of proper provisions for compression and expansion.

Divers going down in search of sponges and corals descend to a depth of 50 m., and thus experience the effects of the compression and expansion which would be obtained in using compressed air at such a depth. It will not be too much, therefore, to say that the ground will be capable of being inspected under all piers before the concrete is filled in at the base. It may also be taken for granted that the bottom can be cleared beforehand by means of a special apparatus, enabling compressed air to be dispensed with, and that the filling of the compartments and air chambers can be effected, either outside or inside the pillars, without its being necessary for the men to perform any important work below.

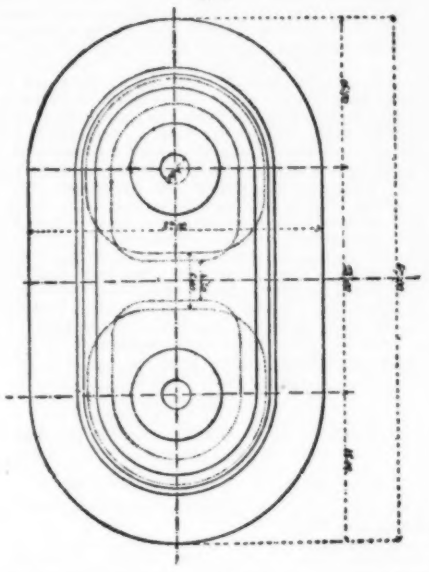
In considering the matter from this point of view, the question arises as to what would happen if the 120 cubic meters of concrete required for filling one compartment were conveyed down through a funnel pipe.

* A paper read at the meeting of the Iron and Steel Institute, Paris, 1889.—*From the Engineer.*

It was found that if the water contained in the lower working chamber can be ejected to make room for the concrete, the filling of such chamber can be satisfactorily completed, and the concrete will in no way be inferior to any of the other methods used for ordinary depths.

This method of carrying down concrete through one continuous pipe is far preferable to the use of cases, which are liable to give off rather considerable quantities of grout. From these remarks it may be inferred that if each compartment was filled in specially and separately from the others, the satisfactory completion of the works would be assured, and that, should any

Fig. 7



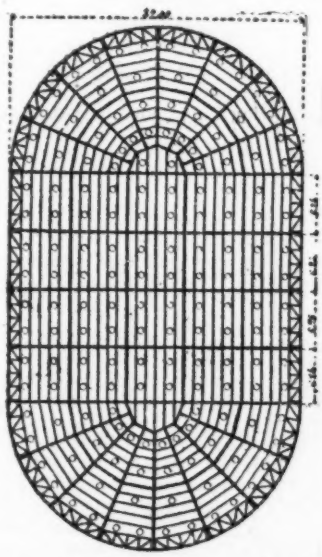
of the compartments not prove quite faultless in some respects, the whole of the work would not on that account be impaired.

These arrangements contemplated for the filling of the compartments have made it possible to determine the shape of the lower portion of the caissons of the piers, and the lines of resistance of the staging. The caissons would have to consist of one externally inclined wall, and of the vertical walls strengthened by strong frames at the portion that is in contact with the ground, and terminating in the form of declivities. All these vertical walls should join the metal roof that separates the lower compartments from the upper portion, and correspond to the upper beams, whose resistance they will thus increase. When the load is sufficiently heavy the declivities will touch the ground, and this contact, at the time of low tide, taken in conjunction with the normal oscillation, will probably be sufficient to break off fragments, which the currents of the sea will remove when high tide sets in.

The chances are that the leveling of the ground can be done without any considerable expenditure of labor; but the cutters will have to be of rather considerable size, in determining which the experience acquired by the sinking of the first caissons near the shore will have to be taken into account.

The leveling apparatus used in the ports of Brest and Cherbourg has already furnished valuable hints on this point. The portion of the caisson situated above the roof will serve to contain the masonry and to protect the same from immediate contact with the

Fig. 8



water, while at the same time it will enable the men employed in the works to operate in a dry place as the structure advances downward. This part of each caisson will be formed of a water-tight metal case, supported by horizontal framings, provided for preserving the external form. All these framings will be inclosed in the masonry, which, in the possible event of the decay of the iron, would remain still unaffected. The portion of each caisson situated above the level of low water will be movable, and can be utilized successively for several piers, which will consist of a sort of dome composed of metal plates suitably fitted to each other. These will cover the structure of the pier and enable the lower ends to be sunk to the sea bottom in such a way that the masonry, although floating, can be completed as if it were erected on land.

This has been successfully achieved in building the dry docks at Saigon and Missiessy, at Toulon, where 45,000 cubic meters of brickwork, representing a weight of 100,000 tons, were kept afloat in the caissons for several months.

The piers, at a depth of 55 m., would have to support the load of 12,000 tons at their juncture with the ground, which is by no means an unheard of achievement.

Figs. 3, 4, 5, 6, 7, 8, and 9 illustrate the general arrangement of the caissons; they show, indeed, the lower portion, or concrete chamber, the central portion containing the ballast masonry, and the top or dome that is to surmount the whole.

Masonry.—The masonry of which the body of each pier is to consist should be composed of good, homogeneous calcareous materials from Marquise, Boulogne, etc., of which there is a great quantity in the neighborhood of Grisnez.

They can be carried to the spot either from Ambleteuse, Boulogne, or Calais, and will cause no trouble. The mortar required for the whole structure will consist of Portland cement, in the proportion of 500 kilos. per cubic meter of silicious or granitic sand. Calcareous or schistose sand must be avoided as liable to decomposition.

Upon the roof of the caissons a layer of concrete 1·50 m. to 2 m. thick shall be formed to protect the iron beams, and above that the ordinary masonry shall be made of rough quarry stones, which shall rise up to the low water level. Two caissons being provided externally, which will render the structure lighter, will greatly facilitate the work on the lower portions, when it is required to fill the chambers of the masonry and the bodies of the piers.

At each successive height of about 4 m. two courses of cut stones will be placed, which will have the effect of better distributing the load and rendering the tendency to settle down more uniform. The level surface of the lower portion below the low water level should also consist of rough stones. From the low water level upward the recesses before mentioned will gradually be made narrower and terminate in two caps, surmounted by funnels, giving access for purposes of inspection and for anchoring the supports of the bridge.

The masonry and the upper portion below the low water level should be fitted with granite stone walls, so as to offer a considerable resistance to the crushing stress and to atmospheric destructive agencies. The platform upon which the metal columns and supports of the bridge are to rest would consist of a number of successive courses of granite stones, which should distribute the weight and loads equally over the surface of the piers, and they will be provided with the necessary holes for anchoring the metal columns to the pillars. Round the platform a metal balustrade should be erected to protect the persons employed in supervision and repairs.

Section 2. The construction, conveyance, and fitting into position of the supporting columns. The port.—The size of the pillars, and the considerable amount of material required, will necessitate the establishment of a port at a point nearest to the spot where the works are begun on either coast. On the French coast, a great construction of that sort would probably have to be provided for in the bay of Ambleteuse, although part of the traffic will still have to be left to the ports of Boulogne and Calais. On the English coast, Folkestone would form the center of operations. The port of Ambleteuse might be established in the free part of the valley, and protected by means of two piers or jetties.

The west pier would point to the north at an angle of 45° to the coast, and the north one would form an incline southward. The entrance would be 250 m. wide, and 7 m. or 8 m. deep at low water. A channel 150 m. wide, protected by a stockade of wood forming a quay for the vessels to come alongside, would give ready access to the port, which would practically consist of the existing port deepened and extended. This port, dug 6 m. deep below the low water level, would be 700 m. long and 350 m. wide, so as to admit of the plant necessary for the simultaneous construction of a number of girders.

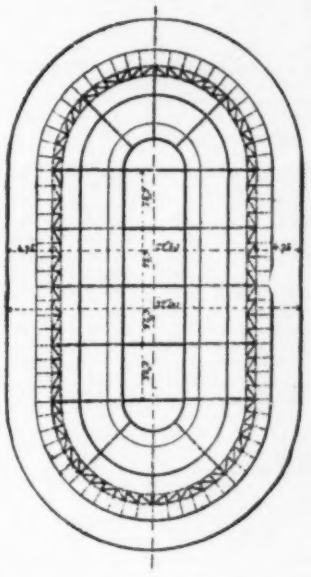
The bottom would be utilized for constructing the foundation of the caissons. Several docks would have to be provided in the port at half tide level or somewhat lower, which would be isolated from each other, and separated from the sea by floating dams, just like a sort of floating docks, that would have to be operated whenever the caisson is taken out, so as to simplify this operation as much as possible. Besides the port a tidal dock would have to be constructed, with quays, bridges, and all necessary arrangements for facilitating the embarking of men and goods, and for insuring the safety of the floating stock.

The northern railway lines will have to lead up to the quays and to any other points that may be deemed desirable, so as to enable all the material and machinery to be carried from place to place by railway, and in order to facilitate the loading, unloading, and storage of same. The dwellings of the workmen will be established at a short distance, but it is very probable that the steamship traffic will permit the employment of workmen residing in Calais or Boulogne, especially to the works to be performed in the offing. It is, moreover, very likely that important quantities of material will have to be conveyed by these ports. This division of labor on the French coast will benefit the whole of the operations, and prevent obstruction of any point of the district occupied by the works. On the coast of England the port of Folkestone and others will be made use of for similar purposes. A network of telephonic cables will connect the different loading stations between them, and also with the yards on land and in the offing, so as to insure that unity of action which is absolutely necessary in the execution of great undertakings such as this.

The first portion of the foundation caissons, which includes the lower chambers, and the cross beams up to a height of 3·50 m. to 4 m., will be constructed in a closed basin, as has been done with the caissons built in Toulon, Antwerp, and Saigun. They will be put afloat by opening the doors at the spring tide, so that they may be brought up to the outer harbor, where the work will be continued. In the outer harbor, then, the erection of metal walls and the caissons will be carried on until a height of from 12 m. to 15 m. above the base is reached. At the same time the ballasting, by means of a layer of concrete from 2 m. to 2·50 m. thick, will be commenced, being intended to insure the necessary stability for conveyance through deep water.

This latter operation can be carried out by means of tugs when the caisson is sunk 10 m. or 12 m. deep, that being the maximum weight that can be charged, lest it should make it difficult to leave the port. The caisson will then, with its ballast of masonry, be brought to the place it will have to occupy, where it will be fixed by the means hereinafter described. The ground will be dug by the ordinary methods, with the aid of

Fig. 9

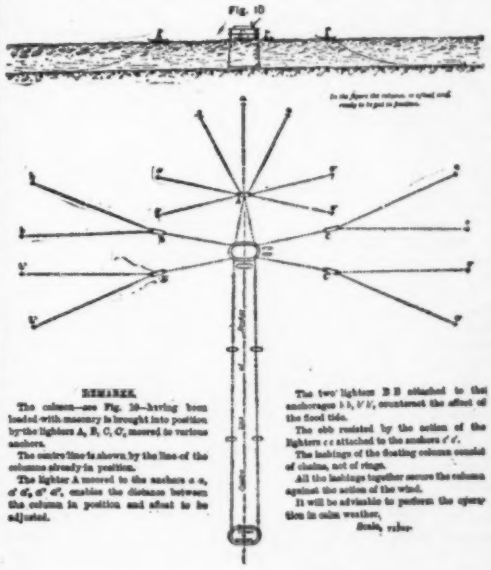


compressed air and other suitable means, until the base is firmly established upon a sufficiently firm foundation.

The chambers on the roof will be filled with concrete and the upper masonry will thus gradually rise until its completion. As regards the pillars to be sunk at a depth of less than 10 m. or 12 m. below low water level, the operation will be as described, but beyond that depth the caisson, when it leaves the port, will be brought up to the pillar that is already placed in position, and the ballasting will be continued up to the time that it has to be taken to the place of its immersion, so as to concentrate as far as possible, at one and the same place, the whole work to be performed in the sea, and thus facilitate surveillance and measures of precaution that cannot be dispensed with in such operations. By thus proceeding step by step, the necessary experience will be acquired as the work goes on for venturing down to lower depths, the work being perfectly regular, and one may say even normal, since it is supported by precedent.

Putting in position.—The most important and perhaps the most delicate operation in this great undertaking is the placing of piers while still afloat, into the positions they are eventually to occupy, with sufficient precision, so that the length of each span of the superstructure may be about equal. Great precautions must evidently be taken, and effects of bad weather avoided, until sufficient experience is acquired. For the first operations, it will always be necessary to work in fair weather and at low water, preferably

Fig. 10


REMARKS.
The caisson—see Fig. 10—having been loaded with masonry is brought into position by the lighters A, B, C, C, moored to various anchors.
The centre line is shown by the line of the columns already in position.
The lighter A moved to the anchors a a, of a', a'' a'', enables the distance between the column in position and afloat to be adjusted.
The two lighters B B attached to the anchorages b b, b' b', counteract the effect of the flood tide.
The ebb resisted by the action of the lighters c c attached to the anchors d d.
The lashings of the floating column consist of chains, not of rings.
All the lashings together secure the column against the action of the wind.
It will be advisable to perform the operation in calm weather.

slack water, so as to be able to touch the ground and fix the construction in a short time. If, after inspection, it should be found that the place where they ground is not the right one, the piers are to be raised, and the whole process to be gone through over again until the column is in its proper place. In fact, the method to be adopted is very similar to that which we used with M. Castor for putting in place the piers of the Arles bridge over the Rhone. At a distance of from 200 m. to 300 m., strong anchors would be run out on chains corresponding to as many barges arranged for supporting and raising them.

These barges will be connected with the caisson of the pier by sufficiently strong moorings to enable it to

be retained in place, to perform the lining out, and to determine the distances, all operations requiring the attendance of very experienced engineers, capable of taking duly into account the deviations due to the action of the tides. The putting into line and fixing the distances may be effected when the edge of the caisson is at a short distance from the ground—say, from 0·50 to 1 m. It will thus be possible to admit into the chambers in the lower portion of the masonry an amount of water that will give the caissons sufficient weight to enable them to touch the ground, and to insure stability, which will make it more easy to ascertain whether they are placed in the right position and are perfectly vertical.

Whenever it might be found that the pier was not in its proper position, it would be necessary, in order to get it afloat again, to let the water out, to replace it by compressed air in the roof, and to begin the same operation afresh. If, on the contrary, the operation proved successful, it will be sufficient, to insure the stability of the caisson, to add to the load a certain amount of masonry, and to withdraw the water or compressed air which had been provisionally used during the ballasting, preliminary to putting in position.

The position of a column being sunk in the midst of anchored barges, and attached by the necessary moorings, will be similar to that of a spider in the middle of its web. By reason of the particular position which each column is to take up, it will probably be necessary to strengthen some of the moorings, and to run out several more anchors. The barges used for that purpose will have to be provided with the necessary steam engines and winches, so as to operate with the necessary amount of safety and power. The same winches can also be used for lifting the anchors. The barges will form a sort of protecting belt to the pier they surround at the moment of its immersion, and will serve to moderate the height and strength of the waves.

It will be possible even to increase this effect of allaying the waves by using open rafts, moored to the barges, which would cover a comparatively large surface of water on the weather side. The employment of oil, as has been pointed out by M. Admiral Clone, has the effect of stopping the breakers, and it is very probable that, after a few experiments, we might, in this way, succeed in obtaining sufficiently smooth water around the piers to enable materials to be put into position under almost any conditions of weather. The experience hitherto obtained of the new means of protection against the action of the sea shows that one may succeed in working, almost without interruption, at floating caissons, as if they were situated on a small island.

Such is the impression which has been deeply engraved upon the memory of all those who witnessed the works carried out in constructing the docks in the port of Toulon. When the moorings are thus arranged near the position of the columns, the masonry of the pier will be built up, the leakings being at the same time tightened, in order to prevent having too much to do at the last moment. The laying of the masonry will compel the continuous raising of the metallic walls of the caisson to the level of the sea at low water. For the purpose of protecting the masonry, after getting each column into position, and bringing the upper portions of the masonry into correct line, the caisson will be surmounted by a movable metal structure, which we may call a dome, on account of its being contracted toward the top. This dome, which will be about 14 m. in height above the fixed portions of the caisson, will be composed of metal plates, one upon the other, and bolted together to the top wall of the caisson, in order to permit of subsequent taking to pieces.

The tightness of the joints will be produced by layers of caoutchouc, as is usually done with dams 80 m. to 100 m. square surface, weighing 80 to 200 tons, employed in foundation caissons. The mounting and taking to pieces of this dome will be managed by means of a floating derrick, capable of lifting a weight of from forty to fifty tons. The lower part of the dome will be furnished with a gallery, or horizontal platform, which will be used at the same time for the purpose of increasing the main resistance. In the middle portion would be another platform or gallery, above high water mark, for receiving the cranes necessary for lifting the materials required for the masonry, after the caisson has been finally placed in position.

Leveling the ground.—Before the caissons are put in place it will be easy to ascertain, by preliminary boring, the nature of the ground upon which the pier would have to rest, and to see whether it is perfectly horizontal or not. These experiments will also permit of making sure that the ground has sufficient resistance to sustain the piers, or whether it is necessary to prepare a special bed for them.

Such leveling of the formation of the bed will probably be requisite in the case of piers near the coast, but owing to the small depth of the sea in those parts, compressed air may be used without any difficulty. For depths of from 20 m. to 35 m., which hitherto have only been obtained in exceptional cases, no uneasiness need be felt with regard to the applicability of compressed air, inasmuch as experience will show the practical improvements that may be made in the methods and means already employed. About twenty-four piers will have to be erected in portions of the ground lying at a depth exceeding 35 m. For these twenty-four piers, the experience previously acquired cannot fail to prove a safe guide as to the improvements that may be made in the methods of operation, and to give practical value to works which hitherto have only been attempted in cases of exceptional difficulty.

Should it so happen, in leveling the ground for the piers that are to descend to the maximum depth, that any danger were to be apprehended from the use of compressed air, there will be no necessity nevertheless to remain inactive, for owing to its rotary structure the ground can be acted upon by means of rotating machinery that can be set in motion from the platform, or it may be cleared and leveled beforehand by means of special machinery.

The clearing of all matter rejected in the leveling operation can be performed by means of force pumps of considerable power, or compressed air engines, whereby the ground operated upon would be divided into a number of sections, to enable the currents to carry away the fragments. Experience will probably show that the action of the water column under pressure will alone be sufficient to clear the ground, and especially to remove all on the surface. The filling of the working chambers with concrete will be effected by means of compressed air, in the case of all the piers that will enable compressed air to be used. There is no doubt that this very important operation will itself suggest various improvements that can be made in the processes now employed, and will meet all requirements in the sinking of most of the piers.

Filling in the concrete base.—It is thought that by repeating the experiments made in the construction of the Kehl bridge, it will be possible, in the case of great depths, to convey the concrete down to the lower portions of the working chambers by the simple use of free air, and to obtain very satisfactory results. One method that is to be thought of in this connection consists in the filling of one of the compartments, having a surface of about 60 m., by one uninterrupted operation, allowing the water and grout that will be produced, or any slime that may be made and left on the ground, to escape through a special orifice placed at the top of the chamber.

To obtain this result a great funnel will have to be used, made of steel sheets, and having a sufficient diameter to allow the concrete to pass through it without too much impediment—75 m. appear, from trials hitherto made, to be a diameter that will answer this purpose. The funnel or tube will have to be filled in with concrete up to the top, and closed at the foot by a "self-closing valve." That would have to be opened so as to permit the immediate passage of enough concrete to fill one of the compartments.

The introduction of the concrete will occupy from fifteen to twenty minutes, so that when the compartment is filled the funnel should still retain a sufficient quantity of it to form a head, and thus to prevent the water from entering the funnel during the operation. In operating in this manner, and in the case of each of the compartments of the lower part of the caisson, it will appear beyond doubt that the foundation leaves nothing to be desired in respect of strength, since the identical operation is gone through for each separate portion.

In fact, the whole of the work will consist in repeating partial operations such as these, for which, therefore, suitable machinery will have to be provided; and it may be considered certain that the normal pressure exercised by the concrete remaining in the funnels will be sufficient for the removal of the slime and grout. The test of such practical data as are available in this kind of work justifies the choice of this mode of operation.

The only objection that occurs to the mind is that it is unlikely for 120 cubic meters of concrete to be got ready in the space of from fifteen to twenty minutes. It does not appear impossible, however, to obtain such a supply, nor even difficult, seeing the enormous quantity of concrete that will be required, and the very powerful machinery that must necessarily be employed. Each pile, when immersed and placed on the ground, will comprise, for a depth of 55 m. below the low water level, the following components:

Displacement of water, at low water	70·513 m.³
" " at high "	75·970 m.³
Difference of tide	5·460 m.³
Volume of the pier	86·000 m.³
Space of the recesses	28·800 m.³
Volume of masonry	57·200 T
Weight of masonry	1·160 T
" caissons	148·870
Load sustained by the ground	150·030
Surface of piers at the base	1·604 m.²
Load expressed in kilos. per square centimeter	9·3 k
Weight of metal columns	2·010 T
" flooring	7·164 T
Total load supported by the ground	157·850
Total load expressed in kilos. per square centimeter	9·8 k

Upper leveling.—Whenever a pier is fitted in position, it becomes necessary to raise the masonry from the lower water level up to the base of the metal portion, that is, a distance of 20 m., and up to a height of 15 m. above the highest water level, so as to protect the base of the metal columns as far as possible from the action of the breakers. This work, which is not inconsiderable, since it represents 12,000 cubic meters of masonry, will, during the first half of the operation, be sheltered by the upper dome, while the last half of the work will have to be carried on after the dome is removed.

The masonry of the upper portion is to be provided with walls of hewn granite stones similar to those composing the upper courses. The body will be an ordinary "filling in" work. Ladders, and even flights of steps, will be provided to facilitate the access of the workmen, or their escape in case of accident. These ladders and steps will also enable the works to be inspected and observed after they are completed.

Erosion at the base.—If any fear was entertained as to the liability of the ground at the foot of the piers to become eroded by the currents of the sea, and thus to become less strong and reliable, it will be necessary to protect them by means of sacks filled with concrete, and so piled up, one above the other, as to form a sort of slope round each pier. Such a result could only be obtained by lowering the sacks of concrete with the aid of winches, as they could not be thrown down.

A good result may also be attained by forming stone packings around the base of the piers, composed of bulky pieces of rock discharged through special doors or gates—as isolated stones would not descend vertically—the probabilities being that no deviation will take place when they are discharged in one bulk through a door. The compression of ground resulting from such rock packing round the piers will even add to its resistance, if that be desirable.

Special considerations.—No construction has been attempted up to the present time unless by means of stones sunk to the bottom, which get displaced or broken above the sea. The sea, in fact, often destroys even piers constructed by rocks, so that the safety of vessels in port is rather jeopardized. It must be recognized, however, that while formerly there was no precedent to assist those employed in the solution of these questions, the experience acquired since has given mankind a great many useful hints by which we ought to profit, and which we must not leave out of sight even when a totally new step has to be taken in the same direction.

Taking for granted that the works will be sufficiently protected against the action of the tops of the breakers, and that it will be possible to shelter them against the less powerful action of the swell, the undulations of which cannot cover more than 100 m. distance from the top of one wave to that of another, or measure more than 2·50 m. from top to bottom, it may be inferred that, in the case of a pier 57 m. long, such a pier will not be thrown out of the perpendicular by any rocking motion to which it may be subjected, and which will only represent a fraction of that sometimes experienced by ships situated near the pier. Piers sunk deep into the water, and forming a considerable bulk, will only undergo part of the effects consequent upon the surface being thrown out of the level, and will present, as already mentioned—even while afloat—the appearance of small islands in regard to the ships that may approach them, while the vessels carrying materials will in most cases follow the undulations of the surface of the sea. The work here contemplated has a certain analogy with the erection of a number of isolated lighthouses upon rocks, which have always caused a considerable expenditure of labor and capital. These works, difficult as they were, did great honor to the able and skilled engineers who had devoted themselves to successfully carrying them out, but it is plain that an immense amount of trouble and labor would have been saved had these very structures been built upon a metal caisson placed upon the bottom of the sea, in the season when that is practicable. The lighthouses in the estuary of the Oder may be mentioned as an instance illustrating this statement, resting as they do on a metal caisson.

(*To be continued.*)

ON EIKONOGEN, A NEW PHOTOGRAPHIC DEVELOPER.*

By Professor G. D. LIVEING, F.R.S.

THIS substance is the sodium salt of amido-β-naphthol-sulphonic acid.

The acid with this long name, $C_{10}H_5.NH_2.OH.SO_3H$, was first described by Professor Meldola in 1881. He obtained it by the reduction of the nitroso-β-naphthol-sulphonic acid (Ch. S. J. xxxix. 47). It has since been obtained in much larger quantity by Witt, by reducing the orange coloring matter from diazo-benzene chloride and Schaeffer's *b*-naphthol-sulphonic acid (Annalen Ch. u. Ph. 152, 298), and he described his process, and the characters of the product, in the "Proceedings" of the German Chem. Society, last December.

It is now produced on the manufacturing scale by the Actiengesellschaft fur Anilinfabrikation at Berlin, and may be obtained in the market, and I think it may be of interest to chemists as well as photographers.

Eikonogen crystallizes well from solution in water, and the crystals contain two molecules of water of crystallization. It dissolves with tolerable facility in hot water, but is only sparingly soluble in cold water, and is insoluble in alcohol. The aqueous solution quickly turns yellow and gradually brown. An alkaline solution turns brown immmediately, from absorption of oxygen. To keep the aqueous solution for any time it is necessary to add sodium sulphite. Even with addition of sodium sulphite, I have found that it does not remain colorless very long.

I need not say that a great variety of reducing agents may be used as photographic developers, but the most essential quality to secure is that the reducing agent shall quickly reduce those portions of the silver compound which have been exposed to light, but shall have no effect, or no rapid effect, on the silver compound which has not first been acted on by light; in fact, that the reduction shall extend to the faintest lights, but shall never spread beyond the particles which have received the impulse of light. Of all substances tried, perhaps pyrogallol has held its own the longest, though some prefer ferrous oxalate, and of late hydroquinone has been a good deal used. The chemical action of hydroquinone is very similar to that of pyrogallol, and the fact that the former is paradihydroxybenzene, and pyrogallol is a tri-hydroxybenzene, led Dr. Andresen, of Berlin, to try the effect of other para-derivatives of benzene which, by oxidation, would easily give quinones or similar substances. Para-di-amido-benzene and para-amido-phenol were found to be well adapted for developing photographs. Subsequently Dr. Andresen turned his attention to the sulphonic acids, and the outcome has been that eikonogen appears to fulfill the requirements of a good developer the best.

Dr. Andresen claims for it:

1. That while eikonogen reduces the bromide of silver so far as it has been subject to the action of light, the bromide in dry gelatine plates which has not been exposed to light remains unaffected by it.

2. That concentrated solutions of eikonogen (1:20 to 1:50) produce even with instantaneously exposed plates minutely detailed negatives.

3. The minuteness of detail produced by eikonogen is supposed to be due to the fine grain of the silver precipitate.

4. The tone of the negatives given by eikonogen is well adapted for printing, and in this respect it excels pyrogallol.

5. The solutions of eikonogen containing sodium sulphite are durable even after the addition of carbonate of soda, and the same solution can be used for several pictures in succession.

6. Eikonogen is not poisonous, which cannot be said of pyrogallol or hydroquinone.

The specimens which I exhibit bear out, I think, the claims. The negatives are remarkably perfect in detail, the tone is excellent, blacker than is given by pyrogallol, more delicate than is given by ferrous oxalate, and the prints from them are very good. I need not say that they have been taken by an experienced photographer.

My own experience of eikonogen is, as yet, very limited, and my practice of photography is limited to spectroscopic photography and negatives. It is necessary for me to have a very sensitive developer, that will develop the faintest details and, at the same time, give

* Read before Section A of the British Association.

all the shades of depth which correspond to variation in the brightness of the spectral lines. Hitherto I have not found anything do so well for my purpose as pyrogallo'; but eikonogen seems as sensitive as pyrogallol, and, at the same time, to give me a picture in which the lines are blacker and more easily seen under a microscope. I cannot quite indorse Dr. Andresen's claim that solutions of eikonogen with sodium sulphite are very permanent. The same solution can, however, be used for several pictures in succession. For instantaneous photographs the solution has to be made alkaline with caustic alkali, and then the liquid becomes brown very quickly. For portraits, and such like pictures, an alkaline carbonate, such as sodium carbonate, may be used.

As regards the non-poisonous character of eikonogen, I suspect it can only be due to its sparing solubility, for so powerful a reducing agent can hardly fail to have a strong effect on the animal economy.

MICA—SOME OF ITS USES.

IN its chemical nature mica is a double silicate of alumina and potash. It is found in all parts of the world, and is a component of granite. In this country it is mined chiefly in North Carolina, and is taken out in blocks of considerable size, which are separated into thin sheets; these are cut to small dimensions for use in stores. Only the clearest and finest sheets can be used. The waste or unused portions form the great bulk of the material. Various modes of utilizing mica waste have been devised. Ground mica is now extensively mixed with oil as a lubricant. As a heat non-conductor mica is useful, and is employed for handles and other purposes when combined with glue, shellac, silicates, etc. The compositions made by Mr. C. T. Lee, of Boston, Mass., are of this kind and he describes some of them as follows:

The object is to produce a tough, solid material which is adapted for use in making handles for stoves, flat irons, soldering irons, pots, kettles, and the like, and for other similar uses where a bad conductor of heat not easily injured by exposure to heat is required.

The compound consists of three ingredients—first, mica powdered or broken into small pieces, or other bodies which, like mica, are refractory to and poor conductors of heat; secondly, gelatine or glue; and, thirdly, salts by which the glue is so altered that it does not become tacky or soft when exposed to moisture.

In preparing the compound liquefy the glue by heat and water, using about one part, by weight, of glue to three parts, by weight, of water, and heating the liquid mass to about the boiling point of water, then mix well into this liquid a solution of the acetate of iron at about 36° Twaddell's hydrometer (22° Baume), using about fifteen parts, by weight, of the solution of acetate of iron for every hundred parts, by weight, of the glue used. The liquid so compounded is then stirred well into a quantity of the mica, which is heated to about 120° Fahrenheit before the liquid is added, and which is kept warm until moulded into the shape desired. This compound, when cooled, will become hard and tough, is not affected by moisture, and is admirably adapted for the purposes above referred to. The best proportions, by weight, of the binding solution and the powdered or subdivided refractory matter are about one pound of the former to one pound of the latter when mica is used; but as this is a question largely of the bulk of the refractory matter and its state of subdivision, it is obvious that the best proportions, by weight, will depend somewhat upon the weight of a given bulk of the refractory matter, and also upon its capacity for absorbing the binding solution. Practically the proper quantity of the solution is easily ascertained, it being that quantity which, when thoroughly intermixed with the refractory matter, will make a somewhat plastic mass substantially free from dry powder.

Another composition consists of mica comminuted so as to form scales or laminæ, varying in size from very small fragments to pieces one-eighth or one-quarter of an inch, or even larger, mixed with shellac in the proportion of about sixty-five parts of mica, by weight, to thirty-five parts of shellac. These proportions may be varied, but the proportions given yield the best results. The mica is incorporated with the shellac by the aid of heat, which softens the shellac, after which any suitable method of mixing the substances may be employed.

Mix them by means of a friction roll mixer, of ordinary construction, consisting of a pair of heated rolls, one roll running at about one-third greater speed than the other roll. The pieces of shellac and mica are mixed and thrown together on to the hot rolls, which revolve side by side and may be adjusted relatively to each other, and as the mixture passes through into a trough or receiver placed underneath, it is again put on to the rolls, and this working is continued until it becomes a plastic mass, when it will adhere to one of the rolls, whence it is skived off with the aid of a knife and laid aside in a flat sheet.

To prepare these sheets for moulding, in case they are allowed to cool, place them on a steam table, and thus heat them until they become plastic and workable again, after which the sheets, or parts of them, of a proper size, are put into hot moulds, moulded under pressure, and allowed to cool. Such a composition will take a clear and fine impression in the moulds, is comparatively light, very strong and durable, and may be used for a great variety of purposes. In mixing the mica and shellac to form a sheet of composition, the laminæ of mica tend to a parallel position, and as they overlap and interlock, the breaking strength of the composition is very much greater than that of compositions in which laminated material is not used. In case the composition is to be moulded, it will be found very desirable to use either shellac alone or a considerable quantity of shellac combined with other resinous gum.

The chief use of the compound is its application to metal handles or other objects to render them non-conductive.

A compound of mica and silicate of soda will be now described.

The mica is reduced in any suitable grinding machine to flakes, preferably of from one-quarter to one-twentieth of an inch in size. The size of the flakes or scales of mica is obviously not of great importance so long as they are small enough to be worked as hereinafter described and not so small as to be too largely reduced to dust or powder, thus practically destroying their flaky character. Mix this comminuted mica with commercial silicate of soda or water glass in the proportion of about two and one-half parts of mica to four of the silicate and enough water to make the mass work well under the trowel. One or more coats of this plastic mass may be placed wherever it is desired to form a surface of low conductivity which will resist high temperatures, or it may be pressed and moulded into solid or hollow objects for the same purpose. In case the compound is to be moulded, the water may be omitted and more silicate of soda used, according to the result desired, whether of a greater or less degree of hardness. It will be clear that the proportion of mica employed will vary somewhat with the uses to which the compound is to be put and whether it is to be moulded or not.

The scales or flakes of mica are preferable to mica dust, since they render the compound stronger and capable of resisting more effectively a higher degree of heat. If the mass is to be moulded, especially into hollow objects, as cylinders and the like, strength is of considerable importance.

Many of the articles made require to be strengthened as, if made of the composition alone, they would be liable to break. To strengthen them, a metal core or strengthening piece is inserted, and the plastic mass moulded around it into the shape desired.

Hitherto difficulty has been experienced in securely uniting the metal core to the composition, and so the composition was liable to come off the core or piece of metal with which it was in contact, and thus destroy the value of the article.

This is a process by which articles moulded from a composition of mica or similar material and a resinous gum can be secured firmly to a metal core or strengthening piece.

One of the mica compositions which is employed, as above referred to, in making moulded objects, consists of ground mica mixed and incorporated with shellac by the aid of heat. The mass, after being thoroughly mixed and while it is in a plastic condition, is placed in dies of the proper shape to mould it to the shape desired in the object which is to be produced, and the moulding is accomplished by the compression of the plastic mass in the dies. These dies are warm. Before the plastic mass is placed in them, the core or piece of metal which it is desired shall be attached to the moulded object is heated until it is hot, that is, has reached a temperature of say 300° Fahrenheit, which is considerably higher than the temperature of the dies or the plastic mass. This core or piece of metal is then placed in proper position within the dies, together with the mass of plastic material, and the dies closed under pressure, compressing the mass and moulding the article to shape around the metallic core. The object is allowed to remain in the dies to cool under pressure, and is then ready for use or further manipulation. Such cooling under pressure prevents expansion of the moulded object and enables the production of an article of exact size and shape, with a close, uniform surface, and the composition part of said article, even if fractured into many pieces, will still remain firmly secured to the metal.

Valuable information concerning the mining of mica as conducted in this country will be found in SCIENTIFIC AMERICAN SUPPLEMENTS, 305, 654, 655, 656, to be had at this office.

ALUMINO-FERRIC CAKE.

ITS COMPOSITION AND USE FOR SIZING PAPER.

ALUMINO-FERRIC cake is essentially a sulphate of alumina with a larger proportion of sulphate of iron than aluminous cake. It is, weight for weight, a stronger sizing material than this latter product, as it contains one-sixth more anhydrous sulphate of alumina, and is indeed almost as strong as many qualities of sulphate of ammonia (so called) which are found in the market. For this and other reasons it is a powerful opponent of aluminous cake, and excepting that it sometimes contains as much as three times the quantity of iron which exists in aluminous cake, it is quite as cheap and answers the requirements of the paper maker quite as well.

Alumino-ferric cake was introduced into the British market by the late Mr. Peter Spence, of alum fame, about the year 1875. Since then vast quantities have been manufactured and consumed by the paper maker in this and in other countries. It is admirably adapted for sizing all kinds of low quality papers, and in certain cases of toned high-class printings, etc. The presence of a small quantity of oxide of iron, which imparts a reddish yellow shade to the finished sheet of paper, does not interfere with the quality of the ultimate product, but rather assists in its production, inasmuch as the iron in the alumino-ferric cake yields by itself in many cases the required shade. The yellowish tone thus produced is, however, very slight, and in the case of "soft sized" printings is almost imperceptible.

This sizing compound is cheap, as an appreciable advantage is gained in cost of freight over that for aluminous cake, there being as above stated about one-fifth or one-sixth more anhydrous sulphate of alumina in it, and about one-third more than in potash alum. The saving in cost of freight is in direct proportion to the relative quantities of sulphate of alumina contained in these salts.

Unlike aluminous cake, it is not obtained by the action of sulphuric acid upon a clay such as kaolin or china clay, but upon a mineral known in trade under the name of bauxite, which consists essentially of a hydrate of alumina. The impurities which the bauxite contains are much greater in extent and more injurious than those in china clay, and consequently the manufacture of a crude sulphate of alumina from it entails considerably more trouble and expense. The bauxite is found in very extensive beds in Ireland, county Wicklow, forming indeed a remarkably curious deposit of oxide of aluminum in combination with water, analogous to the deposits of hydrated ferric oxides known as bog iron ore or as ocker. The bauxite is sold either in lumps or as a powder in bags, and contains from 48 to 52 per cent. of alumina, with varying quantities of oxide of iron and other substances, which, however, have little influence upon the final product when the mineral is dissolved in sulphuric acid. These impurities are earthy substances, insoluble in the acid, and are removed by simply settling the crude dilute aqueous mixture of acid and bauxite; but the iron, which is in the forms of ferrous sulphate (green vitriol) and the sulphate of the peroxide, remains in the clear settled liquor along with the sulphate of alumina, because they are both very soluble salts. When the solution of the crude sulphate of alumina is boiled down to a certain density, it is allowed to solidify in pits, and is then simply broken up or crushed into fragments and sold as alumino-ferric cake in bulk or in bags.

The soluble constituents in bauxite are dissolved out by sulphuric acid in a large lead-lined circular tank provided with a mechanical agitator. The acid is first introduced into the tank and heated by the injection of steam, after which the ground bauxite is gradually added in large quantities at first, or until the chemical action between the alumina and vitriol begins, and then in small quantities of about two or four cwts. at a time. In this way the chemical action is maintained, and it is essential to the success of the operation that this should be so, because it has been found that the solution of the alumina, or the neutralization of the sulphuric acid, then takes place much more easily and more completely. The heat developed by the action of the bauxite and acid is very great, so great indeed that the mixture boils violently in the tank and frequently rises so high as to overflow its sides. When this is imminent, cold water is added to reduce the temperature of the mass, and thus retard the chemical action. After the proper amount of bauxite has been added, and when the charge ceases to foam or begins to get thick, a small quantity (equal to the volume of the acid mixture in the tank) of hot water is added, and the mixture kept hot for an hour or so by the injection of steam while in a constant state of agitation. Care must be taken that the charge is not allowed to cool and thus set hard. The crude mixture of sulphate of alumina and insoluble matter is then diluted with water till it registers 40 or 50 per cent. Twaddell, when the insoluble substances, which amount to about 25 per cent. of the weight of the bauxite, are allowed to deposit. The clear liquid is then siphoned off and boiled down to a density of about 110° Twaddell (hot), and solidified by cooling. In this state it is a soft cake of a brownish color, and possesses on an average the following composition:

ANALYSIS OF ALUMINO-FERRIC CAKE.

Anhydrous sulphate of alumina	47·61 per cent.
Anhydrous sulphate of peroxide of iron	1·80 "
Anhydrous sulphate of lime	0·14 "
" insoluble matter	0·06 "
" water, alkaline salts, loss, etc.	50·39 "
	100·00 "

It will readily be seen from this analysis that so far as the paper maker is concerned, the only impurity contained in alumino-ferric cake is sulphate of iron. The aggregate amounts of alkaline salts, insoluble matter, etc., are very small. The above quantity of anhydrous sulphate of alumina is equal to 14·2 per cent. alumina (Al_2O_3), and the sulphate of peroxide of iron to 0·72 per cent. peroxide of iron. The iron, however, exists in the two forms, viz., sulphates of the protoxide and of the peroxide. We have not expressed the several amounts of these for the sake of simplicity.

Compared with the analysis of the aluminous cake marked "A," which we gave in a recent issue of this journal, the above alumino-ferric cake contains much more iron salt. Whereas the aluminous cake contained 0·18 part of peroxide of iron on 41·8 parts of anhydrous sulphate of alumina, the above alumino-ferric cake contains 0·632 part, or three and a half times as much on the same quality of anhydrous sulphate of alumina. From this it will be seen how much more impure the alumino-ferric cake is to the aluminous cake with respect to the ingredient iron. Whether the increased amount of iron in the cake under consideration has a deleterious effect in the process for which it is used is another question, and one which is not within the scope of this article. That it has an influence in certain typical cases no practical paper maker would venture to doubt, but on the other hand there are instances when it can be used with impunity. For the purpose of sizing brown and grocery papers no better sizing material exists, and in the production of many of the better kinds of low-class papers alumino-ferric cake can be used. Indeed, it may safely be asserted that with few exceptions, where aluminous cake is applicable for the sizing of paper, alumino-ferric cake is equally so. These few exceptions to its use are not very prevalent, and are frequently so well defined that paper makers are well aware of them, and, of course, avoid the use of any ingredient in their sizing or coloring that would vitiate the ultimate required result. The amount of insoluble matter in alumino-ferric cake is very small, but is large enough to alter its appearance to a somewhat earthy brown color. Otherwise the cake would possess a slightly greenish shade. This insoluble matter is in an extremely fine state of division, and consists chiefly of titanic acid, which exists in the original bauxite to rather a considerable extent. It may be removed by dissolving the cake in water and allowing the insoluble matter to settle out.

For sizing brown and grocery papers no such precaution is necessary, for the alumino-ferric cake may be added direct to the pulp in the beater if it be previously broken up or crushed into fragments. The same method may also be adopted for low-class printings. But where it is necessary to have a clear solution of sulphate of alumina for sizing, the alumino-ferric cake is dissolved in water in a special apparatus and a certain volume of the liquor, corresponding to a known weight of dry cake, is measured off and poured into the beater engine. This is always the most satisfactory method of using alumino-ferric cake, and may be carried out in the following way, viz.: A large wooden tank, bound together with wrought iron rods and lined with sheet lead (8 lb. to the square foot), is provided with a perforated false bottom of strong sheet lead, supported on fire bricks placed on edge and so far apart that the liquor will flow freely between them. From underneath this tray or perforated false bottom a strong two inch lead pipe burnt on to the bottom lead lining is brought up along the outside of the tank and bent over in the form of a bib, the curve of the bib

being about 12 inches from the top of the sides. Below the bib end of the pipe a shoot, also lined with lead, runs over the tops of a series of two or more smaller tanks which serve as stores for the aluminous liquor. These store tanks are made of wood lined with sheet lead, and each one has a small antimony regulus tap about six inches from the bottom, from which the liquor is drawn off as required. The alumino-ferric cake is placed in the large tank until the latter is full, and cold water is then run in until the water in the tank is at a higher level than the bottom of the curve forming the bib on the 2 inch lead pipe.

As the water descends through the mass of alumino-ferric cake in the tank it dissolves this salt, the strong solution of which rises in the two-inch pipe, and finally overflows into the shoot, conveying it to any one of the store tanks. Practically speaking, as much liquor runs from the tank as there is water added. The strength of the liquor running into the store tanks may be regulated at will by simply running on more or less water as the circumstances of the case necessitate. As the cake dissolves, more of it must be added, and it is advisable to keep the tank nearly full. If the strength of the aluminous liquor in degrees of Twaddell's hydrometer falls below that which is taken as the standard, it is only necessary to stop the onflow of water, and allow the contents of the tank to remain at rest for a short time. The water may then be run on again, when it will be found that the aluminous liquor has come up to strength. In some cases it is advisable to run the liquor off from the dissolving tank into the store tanks at a higher strength than that required for sizing, because it is then only necessary to add a little water to the liquor in the store tanks to reduce it to the exact Twaddell required.

A cold saturated solution of sulphate of alumina, that is, a solution which cannot dissolve any more of the salt, has a specific gravity of 1·28°, or 58° Twaddell's hydrometer, and the proportion of water to anhydrous sulphate of alumina in this solution nearly corresponds to the chemical formula of the crystalized salt, viz.: $Al_2 3(SO_4) + 18H_2O$. From this it will be seen that alumino-ferric cake is a very soluble salt. In general practice, however, in paper mills it is seldom or never necessary, or indeed advisable, to make and use such a strong solution.

The most convenient way is to fix upon a certain strength of liquor in degrees Twaddell which will contain a known weight of alumino-ferric cake per gallon, such for example as that made by dissolving 2½ lb. of cake in as much water as will make the volume equal to 1 gallon. These proportions will yield an aluminous liquor having a strength of 22° Twaddell at 60° Fah. or thereabout. In this way we have ascertained the amount of alumino-ferric cake in liquors of various strengths, viz.:

19°	Twaddell	liquor	contains	2	lb. per gallon.
22°	"	"	"	2½	lb. "
25°	"	"	"	3½	lb. "

The Twaddell of the liquor made from different lots of alumino-ferric cake will vary within certain limits, according to the variation in strength of the cake itself, but it will be found that the above are sufficiently accurate for use on the beater floor of any paper mill.

The liquor in the store tanks can be reduced to any one of the above strengths when necessary by adding a little water and thoroughly mixing. Care should be taken to have the liquor cold before taking the final gravity. It is quite possible, although a little more troublesome, to run the liquor from the dissolving tank at any of the above strengths by simply regulating the flow of water on to the alumino-ferric cake, and the beater man, knowing how much each gallon of liquor contains, can measure off the exact quantity required and add it to the pulp in the beater engine.—*Chem. Trade Jour.*

DUVEAU'S SPEED REGISTER.

THE illustrations are of a speed register designed by M. A. Duveau, of Rouen, and exhibited by him at the Paris exhibition. In describing the apparatus we borrow largely from the inventor's own description. He says that hitherto nearly all speed-recording instruments depend on centrifugal force, which involves the use of masses in motion that cannot change the condition of their movement instantly under the action of an increase or diminution of speed; hence follows a retardation or an exaggeration in the records made.

The instrument we are describing depends for its action on a mechanical combination giving the proportional of two speeds, one of which is constant and the other variable. In other words, the mechanism of the instrument determines the positions of a needle, taken under the influence of a fixed and of a variable speed, the position varying with the proportions between these two speeds.

The two perspective views (Figs. 1 and 2) show the back and front of this recording apparatus, and Figs. 3 and 4 illustrate its construction. The friction wheel, G, that carries the needle is affected by the two disks, P and P¹, the axes of which do not lie in the same plane, so that the disks are eccentric to each other; upon this eccentricity depends the movement called by M. Duveau the proportional motion.

The apparatus has, therefore, three points of rotation: the center, X, of the disk, P; the center, X¹, of the disk, P¹; and the center, C, of the friction wheel, G. The disk, P, is driven by the machine whose speed is to be recorded, while the disk, P¹, is moved at an absolutely uniform rate by the motor of the apparatus; the former is called by the inventor the engine disk, and the latter the controlling disk; these are driven in opposite directions. The indicating needle is mounted on the axis of the friction wheel, G.

When the disks revolve at equal velocities, and the wheel, G, has fallen to its mean position, that is, midway between the centers, X and X¹ (see Fig. 5), it will be influenced by the disk, P, in the direction of the arrow, V, with a speed corresponding to the radius, X G; and by the disk, P¹, in the direction of the other arrow with a speed corresponding to the radius, X¹ G¹, so that the influence of one balances that of the other, and the needle will remain stationary.

Under these conditions the apparatus would be working at the zero point, assuming the various parts to be in proper order. But if the disk, P, revolves faster than P¹, the friction wheel, G, will be moved toward the point, G², approaching the center, X, and receding from the center, X¹.

By this change the tangential speeds of the points of contact will be modified—that of the disk, P, will be reduced because the length of the radius is smaller; that of P¹ will increase for the opposite reason; the maximum point of difference is, of course, on the line, Y (Fig. 5).

If the differences in speed of P and P¹ are not excessive, the friction wheel will gradually find for itself a point of rest, where the speeds of the points of contact

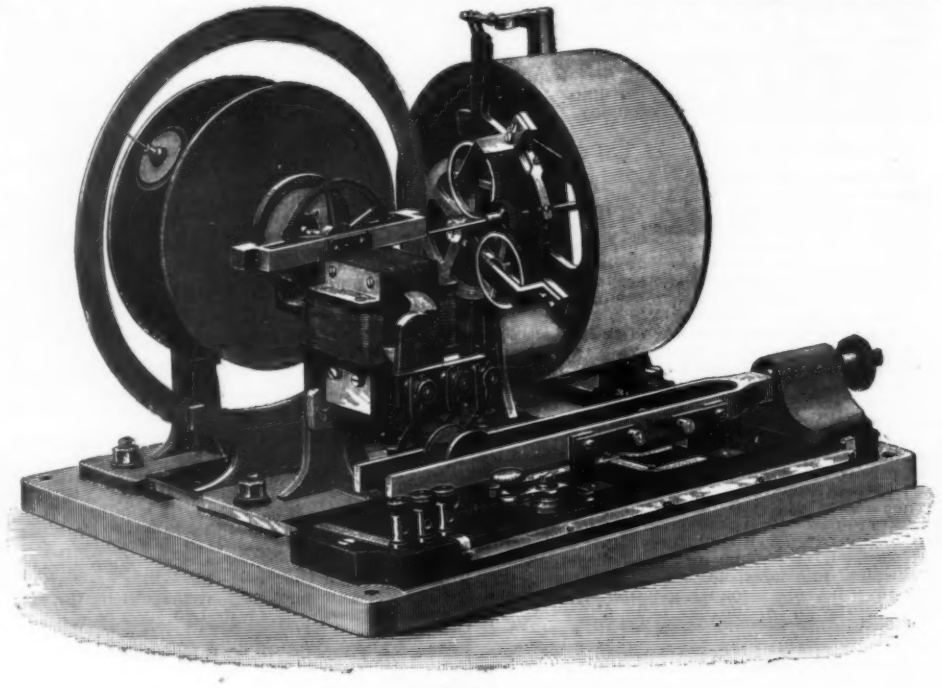


FIG. 1.

with both disks are identical, and the position it then assumes will indicate the proportional speeds of P and P¹. If V and V¹ represent the speeds of the disks, then

$$V \times X\,G^1 = V^1 \times X^1\,G^1,$$

or

$$V : V^1 = X^1\,G^1 : X\,G^1;$$

Then C— the angle $G^1\,C\,Y$ will be the measure of the proportion of differences in the speeds of the disks. If the disk, P, revolves more slowly than P¹, the friction wheel, G, will move toward V¹, and the proportions of the radii will be modified in the opposite direction toward the point, G², then

$$V : V^1 = X\,G^2 : X^1\,G^2$$

The following is M. Duveau's calculation of the angle, C:

Let *a a*, Fig. 6, represent the half eccentricity of the disks; *b* the distance of the wheel, G, from its center of movement, and *c* and c^1 the distances of the points of contact of G from the centers of the disks. C = the angle G C X.

It will be found that

$$\text{Cos C} = \frac{a^2 + b^2}{2\,a\,b}\left(\frac{1-\left(\frac{c}{c}\right)^2}{1+\left(\frac{c}{c^1}\right)^2}\right)$$

In the construction of the speed recorder an eccentricity of 7⅛ millimeters has been adopted, equal to one-tenth the length of the arm of the friction wheel (75 millimeters) or $2\,a - \frac{b}{10}$, and the angle C has been calculated for the positions representing 1, 2, 3, etc., revolutions of difference more or less on 100 revolutions, that is to say, for a uniform speed of 100 revolutions of the disk, P¹, and of 91, 92, 93, etc., and 100, 101, 102, to 110 of the disk, P.

The following table gives the values of the cos C and of the angle C, the displacement of the point corresponding to the angle C, the arm of the lever operating it being 40 millimeters, the differences of these displacements:

Proportion of speeds per cent.	Cos C.	C.			R Cos C. R = 40 mill.	Differences in mill.
		deg.	m.	s.	mill.	
91	0·942672	19	29	41	37·70688	4·34812
92	0·883969	33	29	29	33·35876	4·30888
93	0·726247	43	25	38	29·04988	4·26948
94	0·619510	51	43	11	24·78040	4·22980
95	0·513765	59	5	6	20·55060	4·19001
96	0·409013	65	51	25	16·36052	4·15016
97	0·305259	72	13	34	12·21036	4·11018
98	0·202504	78	18	59	3·10012	4·07014
99	0·100751	84	13	3	4·03004	4·03004
100	0·000000	90	0	0	0·000000	
101	0·099748	84	16	31	3·98992	3·98992
102	0·198495	78	33	36	7·93980	3·94988
103	0·296241	72	46	5	11·84664	3·90984
104	0·392986	66	51	34	15·71944	3·86980
105	0·4887336	60	44	33	19·54934	3·82990
106	0·583486	54	18	14	23·33944	3·79008
107	0·677245	47	22	16	27·08980	3·75036
108	0·770015	39	38	41	30·80060	3·71080
109	0·861799	30	28	51	34·47196	3·67136
110	0·952602	17	42	40	38·10408	3·63212

The apparatus is provided with a dial 210 millimeters

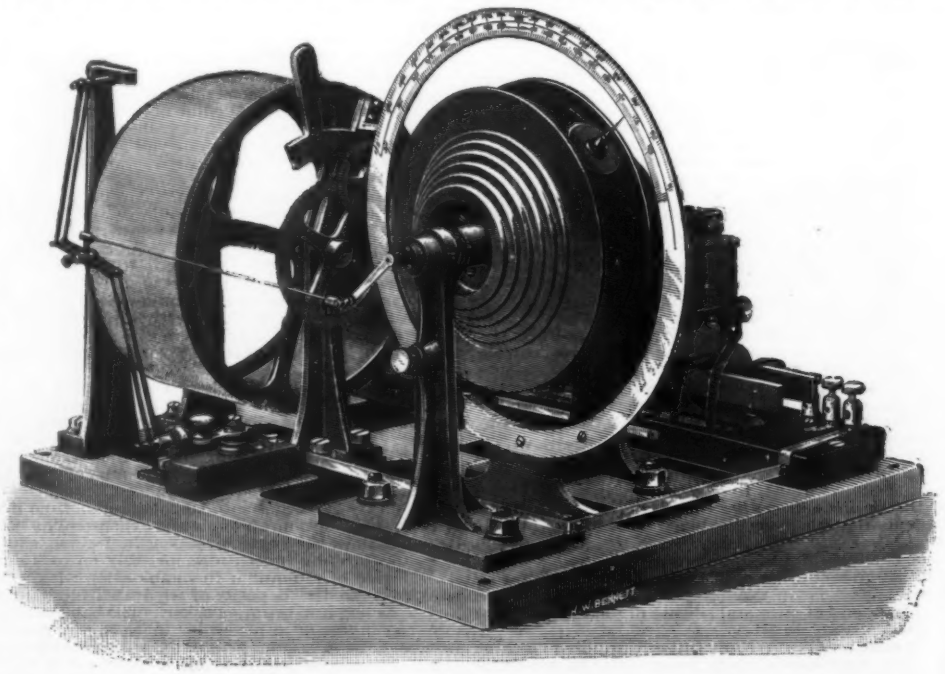
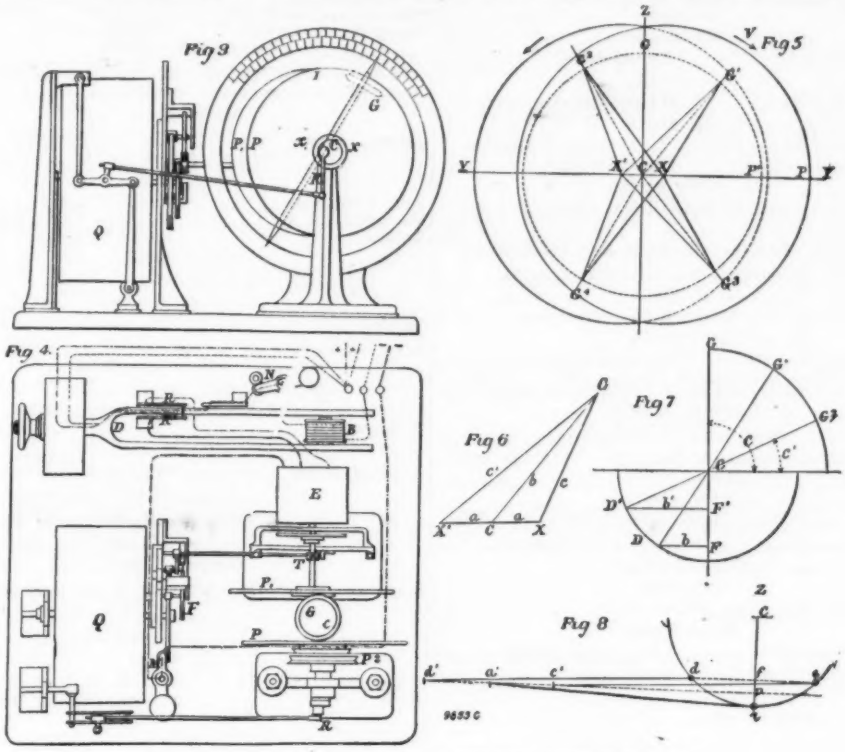


FIG. 2.

DUVEAU'S ENGINE SPEED REGISTER AT THE PARIS EXHIBITION.

(8·26 in.) in diameter, the circumference of which is divided according to the angles, C. The difference in speed from 100 to 101 is marked by a division of 0·39 in. ; the subdivisions by tenths indicate the differences of $\frac{1}{1000}$, and smaller differences can be read up to one-fifth of a millimeter. The divisions, of course, vary in width ; thus between 100 and 110 it is 0·91 in., so that on



DUVEAU'S ENGINE SPEED REGISTER.

this part of this scale the readings can be made up to $\frac{1}{10,000}$. In addition to the readings of the scale, the apparatus supplies means for obtaining diagrams in which the lateral displacements are in proportion to the differences in speed.

The axis of the spindle carrying the friction wheel, G, traverses eccentrically the spindle of the disk, P, and at the end of the former is carried the lever, R (Fig. 4), which is connected to a rod carrying a pencil, and guided by a parallel motion ; this is shown clearly in Fig. 1. The displacement of the pencil corresponding to the angle, C, is then (see Fig. 6) for one position

$$F D = b = R \cos C.$$

For the other position it is

$$F^1 D^1 = b^1 = R \cos C^1.$$

If the adjustment is correct,

$$\frac{R \cos C}{R \cos C^1}$$

ought to represent the proportion of differences of speed. Taking an example from the table, M. Duveau gives the following illustration :

For 94 per cent.	R cos C =	24·78040
95 "	R cos C =	20 55060
Difference.....		4·22980
101 per cent.	R cos C =	3·98992
102 "	R cos C =	7·93980
Difference		3·94988

Now the differences in speed are : between 94 and 95 per cent. = $\frac{1}{94}$; and between 101 and 102 per cent. = $\frac{1}{101}$. Therefore

$$\frac{1}{94} : \frac{1}{101} = 4·22980 : 3·94988$$

and

$$\frac{4·22980 \times 94}{101} = 3·93664$$

Difference.....	0·01324 millimeter,

or $\frac{1}{100}$ millimeter, which is less than the width of a line traced with a point on smoked paper. In order to avoid the error due to the influence of the connecting rod between the lever and the pencil, the center of the pencil is not placed at the same height as the center of the disk, but on the line, $d^1 p^1$, Fig. 8, which divides the versed sine of one-fourth of the circumference, $d\ a\ e$, in two equal parts ; the movement within the arcs, $a\ d$ and $a\ e$, gives a uniform motion to the pencil ; beyond d and e the influence is not felt, as the connecting rod scarcely rises out of the horizontal.

It has already been explained that the friction wheel, G, occupies the position, G^1 (Fig. 5), when the disk, P, is the faster, and the position, G^3, when it is the slower of the two.

On the lower half of the circle are the symmetrical points, G^2 and G^4. At first sight it does not appear evident why the friction wheel should not assume these latter positions, which would, of course, render the instrument useless.

It is clear that the wheel moving from the point, G, toward G^1 when the speed of the disk, P, is increased is influenced by two radii, the proportion of which varies with the proportion of the speeds of the disks, and under these influences it invariably finds a point of rest around which it oscillates as it is affected by the variations of the speed.

But supposing that the wheel was shifted round to the point, G^2, if the speed increases, the wheel would be drawn toward G^4, where the distance of the wheel from the center, X, increases. But the speed of the disk, P, is already assumed to be greater than that of P^1, and the tangential speed would be still more increased by the increase of distance resulting from the displacement of the friction wheel toward V. The wheel would consequently pass through the quarter circle, G^4, rise beyond Y, and find its definite position about the point, G^1 ; for the same reason, if the speed, V, is less than the speed, V^1, and the wheel were placed at the point, G^4, it is necessarily drawn round into its position around G^2.

It is, therefore, the direction of movement that determines the side of the circle that the friction wheel should occupy, and the crank lever to which the pencil rod is attached must consequently occupy a fixed position.

The movement of the disk, P^1, and that of the drum carrying the paper correspond ; it is evident that this movement must be absolutely regular and continuous. The disk is driven through gearing by a small electric motor, E, Fig. 4, which in the instrument exhibited consists of two electro-magnets, the four poles of which form a cross ; each magnet has a separate circuit. One end of each wire goes to the battery, the other end of one wire goes to the spring, R, and the other end of the second wire to the spring, R^1 ; the battery current can, therefore, flow either by R or R^1.

A tuning fork, D, kept in movement by a coil, B, touches the contacts, R and R^1, alternately. The fork, D, is connected with the other pole of the battery at its point of support. The vibration of the tuning fork is maintained by the current from another battery, and by means of a commutator current—regulated by the tuning fork—flows through the coils of the motor, which is thus polarized alternately in the direction of the poles, and a movement of oscillation is set up in the armature. But if the armature is turned at such a speed as to correspond approximately with the currents given through the tuning fork, the movement of revolution is maintained, and the velocity becomes and continues absolutely uniform, and as the speed depends on the number of impulses given through the tuning fork, the motor will continue to work after the battery current has become enfeebled.

The registering mechanism consists of an endless screw transmission, T, on the spindle of the disk, P, and a clockwork, F, that drives the drum, Q, on which the paper to receive the diagram is fastened.

The speed can be varied so as to turn this drum either once an hour or once in fifteen minutes, giving a development of paper of 3·39 in. or 15·75 in. per minute respectively.

In using the instrument the disk, P, is connected to the motor, the speed of which is to be recorded by a cord passing over one or other of the pulleys, P^2 ; the tuning fork is set in vibration, and the friction wheel, G, then drives the disk, P, at the same speed as the disk, P ; the electric motor is started by opening its commutator, and the instrument is in operation. The drum carrying the paper can then be put in movement, and the pencil brought in contact. The diagram produced will be a straight line when the speeds of the two disks are identical, and it will become of varying irregularity with differences in their speeds ; they are sensitive enough to record a variation of $\frac{1}{1000}$ of difference, and irregularities in every part of the stroke of the piston in a steam cylinder are sharply reproduced.—*Engineering.*

THE ZIPERNOWSKY ELECTROSTATIC ELECTROMOTOR.

THE well-known phenomenon that bodies charged with identical electricity repel each other was first used in 1780 by Franklin for the production of continuous motion. He employed a horizontal wheel constructed of horizontal strips of glass fitted at each end with copper balls. The wheel was placed upon a point between the balls of two Leyden jars with opposite charges, so that two diametrical balls of the wheel became charged similarly with those of the jars and were consequently repelled by the latter. After a revolution of 180°, each ball discharged itself on the ball of the opposite Leyden jar, receiving at the same time a part of the electricity there accumulated, and was repelled. Franklin named this apparatus an electrical kitchen jack.

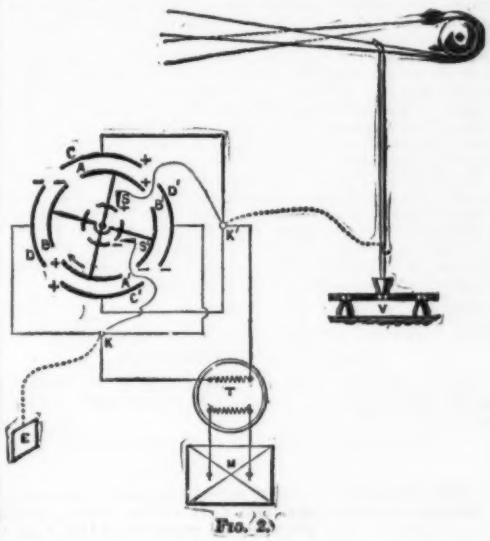


FIG. 2.

Poggendorff subsequently showed that a movable disk of glass or ebonite begins to rotate if opposite electricities are conveyed to it by means of two diametrically opposite combs, and if at the same time it receives an initial impulse in any direction.

Poggendorff also set a Holtz influence machine in rotation by charging the combs of this machine by another influence machine.

In order to study the so-called static effects of high tension alternating currents, Herr Zipernowsky, among others, has constructed a small rotatory apparatus which he derived from Thomson's quadrant electrometer in the idiostatic form indicated by Joubert. Zipernowsky has been able to set this apparatus in rapid motion both with a high tension alternating current

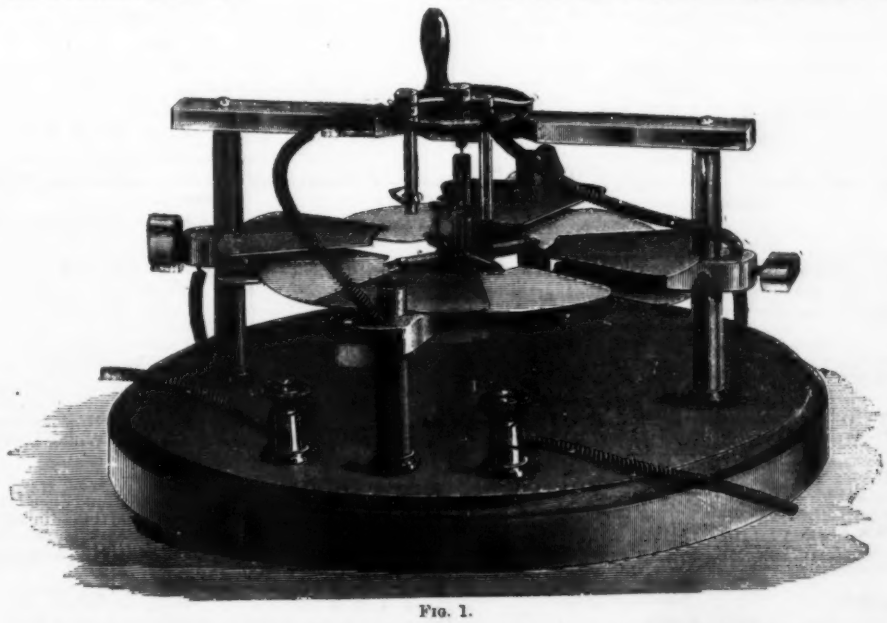


FIG. 1.

THE ZIPERNOWSKY ELECTROSTATIC ELECTROMOTOR.

and with a high tension continuous current. In the former case he introduced the apparatus between the secondary terminals of a transformer whose primary was connected to an alternating current machine of low tension. With 1,000 volts the rotation was so rapid that it could not be followed with the eye.

In the second case he took the electricity from a driving band which connects the shafting in the testing room of the electro-technical department of Ganz & Co.'s establishment with the motor, a high speed steam engine. In this case the number of rotations was much greater than with a 2,000 volt alternating current. Our London namesake publishes the following description of this machine:

Fig. 1 gives a perspective view of this small motor, and Fig. 2 a diagrammatic representation, with the arrangement of connections shown in both the cases.

The movable part of the apparatus consists of two pairs of aluminum sectors, insulated from each other, which, for the sake of perspicuity, are represented in Fig. 2 as the quadrants, A A', B B'. The fixed part consists of four double (hollow) sectors of brass which inclose the movable sectors, and which are also shown in the diagram as the quadrants, C C', D D'. The movable part is further fitted with a commutator in four parts, by means of which the two pairs of sectors, A A' and B B', are charged identically with the opposite fixed pairs of sectors by means of the points, S S'. If the clamps, K K', are connected with the terminals, S S', of the transformer, T, which converts the low tension of the alternating current machine, M, into a high tension, the apparatus begins to revolve spontaneously unless the movable sectors are placed exactly opposite to the fixed ones. The same takes place if one clamp is connected with the receiving device, V, and the other is connected with the earth. It must be remarked that in this second arrangement a momentary charge of the movable sectors would suffice, as the fixed segments do not alter the sign of their charge. In the former arrangement the charge must be continued, so that the electricities in the fixed and the movable parts may change their signs simultaneously.

It is possible that this apparatus, in some form or other, will be suitable for practical purposes, *e. g.*, as a volt counter for arc lamps in series, as a registering apparatus for the resistance of earth connections, or for changes in the primary tension in alternating current circuits, and perhaps in the case of very high tensions as a motor.—*London Electrical Review.*

[Continued from SUPPLEMENT, No. 722, page 11535.]

THE PARIS EXHIBITION.

LIST of awards to citizens of the United States, September 29, 1889. Specially compiled for the SCIENTIFIC AMERICAN from the official list of awards.

Group III.—Furniture and Accessories.

CLASS 19.—CRYSTALS, GLASS WORK, ETC.

Grand Prize.

Hawkes, T. G.

Gold Medals.

Heidt, Louis. Henry, Edward.
Lafarge, John. Macbeth, George A. & Co.

Silver Medals.

Buffalo Stained Glass Works. Greenough, Walter C.
Healy & Millet. Tiffany & Co., New York.

Bronze Medals.

Edwin Fort. Fromont, Henry.
Pacific Art, Glass, John Mallon.

CLASS 20.—CERAMICS.

Gold Medal.

Rookwood Pottery.

Bronze Medal.

Low, J. G. & J. F.

CLASS 22.—TINTED PAPERS.

Silver Medal.

Warren, Lange & Co.

Bronze Medal.

Wemple, Jay C. & Co.

CLASS 24.—GOLD AND SILVER WARES.

Grand Prize.

Tiffany & Co.

Gold Medal.

Gorham Manufacturing Company.

Honorable Mention.

Bunker.

CLASS 25.—ARTISTIC METAL WORK.

Silver Medal.

Laughlin, M. G. & Mme. Louise.

CLASS 26.—HOROLOGY.

Silver Medals.

Gardner, Seth Thomas. Heinrich, H. H.

Bronze Medals.

Giles. Tiffany & Co.

Honorable Mention.

Kahenn, A. & Co. Roger & Co. Trenton, Vatch & Co.

CLASS 27.—APPARATUS AND PROCESSES FOR HEATING—APPARATUS AND PROCESSES FOR LIGHTING, NOT ELECTRIC.

Silver Medals.

Bernales, De & Co. Rochester Lamp Co. Simpson.

Bronze Medals.

Michigan Radiator and Iron Manufacturing Co.
Pike, W. K.

Honorable Mention.

Dopp & Son, H. W. Frank, J. A.
Huquelle & Co. Reid, Adam.
Philadelphia Novelty Manufacturing Company.
Shepard & Co. Vizet.

CLASS 28.—PERFUMERY.

Gold Medals.

Colgate & Co. Ladd & Coffin.

Silver Medals.

Lorenz, George. Ricksecker.

Bronze Medals.

Mann & Co. Rottenstein & Farley.

Honorable Mention.

Dousan French Perfumery Company.
Leesburg Manufacturing Company.
Hastrick. Sheffield.

CLASS 29.—LEATHER GOODS, TOYS, BASKET WORK, AND BRUSHES.

Gold Medals.

Demuth, W. & Co. Tiffany & Co.

Silver Medals.

Estes, E. B. & Sons. Gorham Manufacturing Co.

Bronze Medals.

Bissell Carpet Sweeper Co. Castle Carpet Sweeper Co.
Horsey Manufacturing Co. Howard Strop Co.

Honorable Mention.

Bailet, J. C. Schramm, H. Gottfried. Torrey, J. R. & Co.

Group IV.—Fabrics, Clothing, and Accessories.

CLASS 30.—COTTON THREADS AND FABRICS.

Gold Medal.

Garner & Co.

Silver Medals.

Atlantic Mills. Willimantic Linen Co.

CLASS 31.—LINEN AND HEMP THREADS AND FABRICS.

Honorable Mention.

United States (collectively).

CLASS 32.—THREADS AND FABRICS OF COMBED AND CARDED WOOL.

Silver Medal.

United States (collectively).

CLASS 35.—HOSIERY AND UNDERWEAR—ACCESSORIES TO WEARING APPAREL.

Gold Medal.

Mayer, Strouse & Co.

Silver Medals.

Folmer, Clogg & Co. Lyon, Amasa, & Co.
Roth & Goldschmidt. Sigels Brothers.

Honorable Mention.

American Braided Wire Co. Chanu. Noyes & Co.

CLASS 36.—CLOTHING FOR BOTH SEXES.

Grand Prize.

Stetson, John, & Co.

Gold Medals.

Beneke Brothers. Dunlap & Co.
War Department. Schloss & Co.

Silver Medals.

Franklin. Friedlander. Senaker, Alfred. Shillaber & Co.

Bronze Medals.

Madame Dellac. Hough & Ford.

CLASS 37.—ORNAMENTS AND JEWELRY.

Gold Medal.

Tiffany & Co.

Silver Medal.

Fairchild.

Honorable Mention.

Fradley. Horton, Angell & Co.
Kant & Stanley. Rider.
Wibel, Geo. & Barber, R. P.

CLASS 38—PORTABLE ARMS.

Grand Prize.

Winchester Repeating Arms Company.

Gold Medals.

Colt's Pat. Fire Arms Manufacturing Company.
Smith & Wesson. Union Metallic Cartridge Co.

Bronze Medal.

Standard Target Company.

Honorable Mention.

Bailey, Farrell & Co.

CLASS 39.—ARTICLES FOR TRAVELING AND FOR THE CAMP.

Gold Medals.

Boston India Rubber Shoe Company.
Marks Adjustable Folding Chair Company.

Silver Medal.

Folding Trunk Company.

CLASS 40.—TOYS.

Bronze Medal.

Gendron Iron Wheel Company.

Honorable Mention.

Howard, A. H. Pierce, Geo. N. & Co.

Group V.—Extracting Industries—Raw and Worked Products.

CLASS 41.—MINERAL AND METALLURGICAL PRODUCTS.

Grand Prize.

Ores and Minerals of the United States.

Gold Medals.

Anaconda Mining Company. Corbin, P. & F.
Delaware & Hudson Canal Co. Drake Co.
State of Nevada. Ranpole, J. B.
The Cowles Electric Smelting and Aluminum Co.
Yale Manufacturing Company.

Silver Medals.

American Bit Brace Co. Enterprise Mfg. Company.
Foote, A. E. Ontario Mine, Utah. White, L. & L. J.

Bronze Medals.

Abraham Brothers. Adam, J. S. & Co.
Alice Gold & Silver Mining Co. Ausable Horse Shoe Nail Co.
Capital Manufacturing Co. Cleveland Tin Mining Co.
Comet Mine. Dickerson Suchasumy Mining Co.
Harnley Peak Tin Co., The. Hartman Mfg. Company.
Hartshorn. Knapp, J. D. C.
Knowd, John J. Miller Lock Company.
Peck, A. G. & Co. Puget Sound Iron Co.
Shephard, Sidney & Co. Smith, John E. & Sons.
Stanley Rule and Level Company.

Honorable Mention.

Adirondack Pulp Co. Brainerd Quarry Co.
Brevington. Castle, William H.
Copper Basin Mining Co. Franck, F. A. & Co.
Hamlin, Dr. Aug. C. International Specialty Co.
Jewet, John C. Mfg. Co. Laurence, R. F.
Maris Machine Co. Meis, General.
New England Brown Stone Co. Nutrizio.
Philadelphia Novelty Mfg. Co. Reid, A. H.
Shaler Hall Quarry Co. Magnolia Society.
Standard Target Co.

CLASS 42.—PRODUCTS OF THE WORKINGS AND OF THE FORESTRY INDUSTRIES.

Gold Medals.

Jackson, Arthur. Korbel & Brothers.
Ministry of Agriculture.

Silver Medals.

Acme Company. Hough, Romeyn.
Massachusetts, A. Northern Pacific R.R.
Rothrock. Sargent, Charles.

Bronze Medal.

Cordley & Hayes.

Honorable Mention.

Brooks. Fayerweather.

CLASS 43.—PRODUCTS OF THE HUNT—PRODUCTS, IMPLEMENTS, ETC., FOR FISHING.

Gold Medals.

The Plantano, Jacksonville, Tampa and Key West.
Tiffany & Co.

Silver Medals.

Newland, Henry A. William Mills & Sons.

Bronze Medal.

Davidson, H. E.

Honorable Mention.

Osgood, N. A.

CLASS 44.—AGRICULTURAL PRODUCTS NOT USED FOR FOOD.

Grand Prize.

Department of Agriculture, Washington, D. C.

Gold Medals.

Cotton Oil Product Co. Dutton, H. F. & Co.
Haas, L. S. Southern Cotton Oil Co.
Vaughan & Sarvay.

Silver Medals.

Allen & Ginter (Incorporated). Bowman, N. R.
Boyee, S. G. Clarck, Washington A.
Harthill, Alexander. Hinson, W. G.
Kimball, W. S. & Co. Roberts, R. R.
Sioux City Linseed Oil Works.

Bronze Medals.

Griffin, S. M. & Co. Straiton & Storm.
Stubbs, Prof. W. C. Thornton, Noble & Davis.

Honorable Mention.

Bruce. Tremery, Felix. Jackson, Arthur C.
Martinez-Ybor. Neal T. D. Noblin & Hudson.
Shelburn. Winston, Frank.

CLASS 45.—CHEMICAL AND PHARMACEUTICAL PRODUCTS.

Gold Medals.

Boston Rubber Shoe Co. Cheseborough Company.
Devoe & Co. Pease.
Revere Rubber Company. Valentine & Co.
Borne, Scrimser & Company. Brown & Company.
Cotton Oil Product. Fairchild Brothers.
Seabury & Johnson. Upton.
Warner & Co.

Bronze Medals.

Bell Manufacturing Co. Brookhaven Rubber Shoe Co.
Crane. Le Page & Co.
Magleish. Russia Cement Company.
Sphingter, Grin & Co.

Honorable Mention.

Armour & Co. Collins Sons & Co. Johnston.
Lugano. Ward.

CLASS 46.—CHEMICAL PROCESSES OF BLEACHING, DYEING, PRINTING, AND STIFFENING.

Gold Medal.

Garner & Co.

Bronze Medals.

Bancroft, John, & Bloede, Victor.
Wiggins, H. B. Sons.

CLASS 47.—LEATHER AND HIDES.

Grand Prize.

Salomon.

Gold Medals.

Barnet, J. S. & Brother. Blanchard.

Silver Medals.

Benz, Diestch & Co. Burck Brothers. Walin.

Group VI.—Apparatus and Processes of the Mechanical Industries—Electricity.

CLASS 48.—MATERIALS FOR THE WORKING OF MINES, AND METALLURGY.

Gold Medal.

Ingersoll Rock Drill Co.

Silver Medal.

Black, Theodore.

Bronze Medal.

Sperry & Company.

CLASS 50.—MATERIAL AND PROCESSES OF AGRICULTURAL WORKS AND FOOD INDUSTRIES.

Gold Medals.

Department of Agriculture. Howes, Simeon.
Maillard.

Silver Medal.

Heine.

Bronze Medals.

Amiger. Phillips. Smith, John.

Honorable Mention.

Enterprise Manufacturing Company.

CLASS 51.—MATERIALS FOR THE MECHANICAL ARTS, FOR THE PHARMACY AND THE TANNERY.

Silver Medal.

Dolph.

Bronze Medals.

Bayley. Benzen. Vizet.

Honorable Mention.

Frank & Company.

CLASS 52.—MACHINES AND APPARATUS FOR GENERAL MECHANICS.

Gold Medals.

American Elevator Co. Armington & Sims.
Brown, C. H. & Co. Otis Bros. & Co.
Straight Line Engine Co. Wheelock, Jerome.

Silver Medals.

Douglas, W. F. R. Thompson, John.
Underwood Mfg. Company. Westinghouse Machine Co.

Bronze Medals.

Dodge Mfg. Co. Emerson-Midglet.
Goulds Mfg. Co. Mason Volney W. & Co.
Pickering Governor & Co. Reed, Y. Van D.
Schieren & Co. Silver, Deming Mfg. Co.
Stater, Frank. United States Metallic Packing Co.

Honorable Mention.

Chicago Rawhide Co. Wilson & Roake.

CLASS 53.—MACHINE TOOLS.

Grand Prize.

Brown & Sharpe. Sellers, Wm. & Co.

Gold Medals.

American Screw Co. Simonds, G. F.

Silver Medals.

American Tool Machine Co. Bliss & Co.
Morse Twist Drill and Machine Company.
Sternberg. Tannite & Co.
Warner & Swasey.

Bronze Medals.

Curtis & Curtis. Jackson, Th.

Honorable Mention.

Horton, E. & Son. Jower & Lyon.
Upton. Whiton, D. E. Machine Co.

CLASS 54.—SPINNING AND ROPE MAKING MATERIALS AND PROCESSES.

Gold Medal.

National Cordage Company.

Bronze Medals.

International Wool Improvement Co.

CLASS 55.—WEAVING MATERIALS AND PROCESSES.

Gold Medal.

Eureka Fire Hose Company.

CLASS 56.—MATERIALS AND PROCESSES FOR SEWING AND MAKING GARMENTS.

Grand Prize.

International Buttonhole and S. M. Co.
Wheeler & Wilson S. M. Co.

Gold Medals.

Davis S. M. Co. New Home S. M. Co.
Paine Shoe Lasting Co. Singer S. M. Co.
Societe anonyme pour l'exploitation des brevets. (Society for Exploitation of Patents.) France and United States.
White, S. M. Co.

Silver Medal.

Johnson.

Honorable Mention.

Eaton. Tillinghast, S. M. Wingate, Mme.

CLASS 57.—MATERIALS AND PROCESSES FOR MAKING FURNITURE, ETC.

Grand Prize.

Fay, J. A. & Co.

Silver Medals.

Casey Machine Supply Co. MacCoy, James S.
Schwab.

Honorable Mention.

Chapman. Lewis & Lewis. Silver & Deming.

CLASS 58.—MATERIALS AND PROCESSES FOR PAPER MAKING, TINTING, AND PRINTING.

Gold Medal

MacKellar, Smiths & Jordan & Co.

Silver Medals.

Golding & Co. Thompson.
Thorne Type Setting Machine Co.

Honorable Mention.

Campbell Printing Press Manufacturing Co.
Miller, Edward L.

CLASS 59.—MACHINES, INSTRUMENTS, AND PROCESSES USED FOR VARIOUS PURPOSES.

Gold Medals.

American Writing Machine Company.
Hammond Type Writer Company.
Remington Standard Type Writer Company.

Silver Medals.

Clough & MacConnell.
Columbia Type Writer Manufacturing Co.
Kruse Check and Adding Machine Co.
Leinback. Myers. Williams Co.

Bronze Medal.

Hall Type Writer Company.

Honorable Mention.

National Cash Register Company.

CLASS 60.—COACH MAKING, HARNESS MAKING, AND SADDLERY.

Grand Prize.

Healey & Co.

Silver Medals.

Chapman Mfg. Co. Dann Brothers & Co.
Kimball, C. P. & Co. Shepard, H. G. & Sons.
Martin & Martin.

Bronze Medal.

Seco, Henry.

CLASS 61.—RAILWAY MATERIALS.

Grand Prize.

Pennsylvania Railroad Co.

Silver Medal.

Peckham Street Car Wheel and Axle Co.

Bronze Medals.

Laird, B. F.
Merchants Despatch Transportation Company.
New York Commercial Company (limited).
Porter, H. & K. & Co.

Honorable Mention.

Boyden Power Brake Co. Fisher.
Inloes, W. H. New York Car Wheel Works.
Railway News Co. Warren, A.

CLASS 62.—ELECTRICITY.

Grand Prize.

American Bell Telephone Co. Edison.
Elihu Thomson. Elisha Gray.

Gold Medals.

Cobb Vulcanite Wire Co. Heisler Electric Co.
Okonite Co. Sprague.
Volta Graphophone Co., The. Western Electric Co.

Silver Medals.

Commercial Cable Company.
Consolidated Telegraph and Electrical Subway Co.
Electric Manufacturing. Sperry, Elmer A.

Bronze Medals.

Electrical Supply Co. Solar Carbon Co.

Honorable Mention.

Medberg. Munson Lighting Co. Warton.

CLASS 63.—CIVIL ENGINEERING, PROCESSES AND MATERIALS FOR PUBLIC WORKS AND ARCHITECTURE.

Grand Prize.

Government Bureau of Engineers.

Gold Medals.

Herring & Co. Yale & Towne Mfg. Co.

Silver Medals.

American Road Machine Co. Corbu. Miller Lock Co.

Bronze Medal.

Brookly Railroad Supply Co.

CLASS 64.—HYGIENE AND PUBLIC AID.

Gold Medal.

Soldiers' Home at Hampton, Virginia.

CLASS 65.—MATERIALS FOR NAVIGATION AND SALVAGE.

Gold Medal.

Inman Company.

Bronze Medal.

Norton Yacht Neversink.

Honorable Mention.

Allen.

Group VII.—Alimentary Products.

CLASS 67.—CEREALS, FARINACEOUS PRODUCTS AND THEIR DERIVATIVES.

Grand Prize.

Department of Agriculture.

Gold Medals.

Board of Trade. Glen Cove Mfg. Co.
Northern Pacific Railroad. Pillsbury, Ch.
Wiley.

Silver Medals.

Butler, A. Schumacher.

Bronze Medal.

Street & Co.

Honorable Mention.

Mansfield, Miss.

CLASS 68.—BAKERY PRODUCTS.

Bronze Medal.

Queen City Chemical Works.

CLASS 69.—PRODUCTS OF THE DAIRY, AND EGGS.

Gold Medals.

Green Mountain Stock Farm. Michner, J. H. & Co.

Silver Medals.

Armour & Co. Cassar & Co. Morell & Co.
Salmon. Southern Cotton Oil Co.

Bronze Medals.

Hooper, Geo. F. Rixford.

Honorable Mention.

Luidi Bagnoli. Swift.

CLASSES 70 AND 71.—MEATS, FISH, VEGETABLES, AND FRUITS.

Gold Medals.

Armour & Company. Cassard, G. & Co.
Curtice Brothers. Michener, S. H. & Co.
Morris & Co. Swift & Co.

Silver Medals.

Brougham, Geo. Cowbry, E. T. & Co.
Franco-American Soup Co. Department of Agriculture.
Nubsen, W. & Son. Pacific Orchard Cannery.
Richardson & Robbins. Rosa, John.
Van Deman. Van Nostrand & Co.

Bronze Medals.

Erie Preserving Co. Griffin Canning Co.
Florida State Horticultural Society.
Huckins, S. H. W. & Co. Humbert, Henry & Co.
Mallory, E. B. & Co. Martin, Wagner & Co.
Myer, Thomas & Co. Perry, F. H.
Sears & Nichol. Winterport Packing Co.

Honorable Mention.

Brown, Arthur. Claget, Thomas.
Hooper, Geo. F. Kennon, Gray & Co.
Kimball, Frank A. Onstott.
Plant, Jacksonville Rampa. Rixford, G. P.

CLASS 72.—CONDIMENTS AND STIMULANTS, SUGARS, AND CONFECTIONERY.

Section II.—Chocolates, Confectionery.

Bronze Medals.

Dedant, Chas. & Sons. Fosweth, A.
Heinz, J. & F. Wilbur. Viley.

Honorable Mention.

Adams & Sons. Consvert, Springer.
Convent des Saintes-Augustines. Douglas, Sugar.
Lutted, James. Newcomb.
Preserving; E. Ross, Mary E.

Section III.—Liquors.

Silver Medals.

Bolen & Byrne.

CLASS 73.—FERMENTED BEVERAGES.

Section I.—Wines.

Gold Medals.

Chauche, G. A. Claret Megliavalla. Wetmore, Chas.

Silver Medals.

Beck, Ad. Beringer, Bion.
Greenbaum. Haraszthy, Aspad & Co.
Henry Hagner. Hooper, Geo.
Kohler & Frohling. Monticel Wine Co.
New Urbana Wine Co. Pleasant Valley Wine Co.
Schilling, C. & Co. Stone Hill Wine Co.
Turk, De. Wineberger, M. J. C.

Bronze Medals.

American Wine Co. Aubonin, H.
Brund & Co. Gundlach & Co.
Krug, Chas. Matthews, J.
Purity Wine Co. Russow, A.
Rutherford, Adamson. Syckman, G.
University of California.

Honorable Mention.

Ben Lomond Wine Co. Edge Hill Wine Co.
Ewer & Akinson. Florida Wine.
Gast Wine Co. Grosmann, H.
Pearson, Alex. M. Schram.

Section II.—Spirits.

Gold Medals.

California State. Osborn Son & Co.

Silver Medals.

Hagen, H. Hume & Co. Napa Valley.

Bronze Medals.

Crabb. Edge Hill. Turk, De.

Honorable Mention.

Kreug, Ch. Noveau Clos-Vougeot.

Section III.—Beers.

Grand Prize.

Berguer & Engel.

Gold Medals.

Beadleston & Woerz. Kunz, Joseph.
Montgomery Brewing Co.

Section IV.—Cider.

Gold Medal.

Mott.

Group VIII.—Agriculture, Viticulture, and Pisciculture.

CLASS 73 (BIS).

Grand Prize.

Department of Agriculture.

Gold Medals.

Commissioner of Agriculture of the State of Kansas.
Dodge, G. R., Statistician of the Department of Agriculture.
Fernow. Saunders.

Silver Medals.

Galloway. Meriam. Salmon.

CLASS 73 (TER).—ORGANIZATION, METHODS, AND MATERIALS FOR AGRICULTURAL INSTRUCTION.

Silver Medals.

Atwater, W., Chief of the Department of Agriculture, Washington.
Taylor, T., Chief of the Department of Agriculture, Washington.

CLASS 49.—MATERIALS AND PROCESSES FOR RURAL AND FORESTRY EXPLOITATION.

Grand Prize.

McCormick Harvesting. Wood, Walter A.

Gold Medals.

Batchellor Sons & Co. Johnston Harvester Co.
Whitmann Agricultural Co.

Silver Medals.

Armour & Co. Chadborn & Coldwell.
Dannlesco, Janeo V. G. Douglas.
Johnston, Samuel, Co. Lloyd & Supplee Hardware Co.
Osborn.

Bronze Medals.

Benson. Bradley & Co.

Honorable Mention.

Planett & Co.

CLASS 74.—SPECIMENS OF RURAL EXPLOITATIONS AND AGRICULTURAL WORKS.

Gold Medals.

Enterprise Manufacturing Company.
Richmond Cedar Works.

Silver Medals.

Jackson. Reid, A. H., Philadelphia.
Wickes Belingerator Co.

Bronze Medals.

Cooley. Howe-Leroy.

Honorable Mention.

Salmon, D. E.

CLASS 75.—VITICULTURE.

Gold Medal.

Clayton.

CLASS 76.—USEFUL INSECTS AND HARMFUL INSECTS.

Grand Prize.

Department of Agriculture of the United States.

Gold Medal.

Collective Exposition of the United States

Silver Medal.

Dadant.

Bronze Medal.

Newcomb.

Group IX.—Horticulture.

CLASS 83.—GRAINS AND FOREST PLANTS.

Bronze Medal.

Fernoux, Director in Chief of Forests.

Social Economy.

SECTION 2.—PARTICIPATION IN PROFITS—ASSOCIATIONS FOR CO-OPERATIVE PRODUCTION.

Gold Medals.

Gilman, Nicholas P. Nelson, N. O.
Publication Agency of Johns Hopkins University.
Wright, Carroll D.

Silver Medal.

Peacedale Manufacturing Co.

Bronze Medals.

Century Co., New York. Rand & McNally, Chicago.
Yale & Towne, Stamford, Conn.

SECTION 3.—PROFESSIONAL SYNDICATES.

Grand Prize.

Department of Labor of the United States.

Gold Medal.

Universal Peace Union of Philadelphia.

CO-OPERATORS.

Gold Medals.

Department of Labor of the State of Massachusetts.
Department of Labor of the State of New York.

Silver Medals.

Department of Labor of the State of Connecticut.
Department of Labor of the State of Illinois.
Department of Labor of the State of Rhode Island.
Department of Labor of the State of Ohio.
Department of Labor of the State of Iowa.
Department of Labor of the State of Kansas.
Department of Labor of the State of Michigan.

SECTION 4.—APPRENTICESHIP.

Grand Prize.

Department of the Interior, Bureau of Education, Washington.

Silver Medal.

Cornell University, Ithaca.

SECTION 11.—WORKINGWOMEN'S HOMES.

Silver Medal.

Tenement House Building Company, New York.

SECTION 12.—WORKINGMEN'S ASSOCIATIONS.

Gold Medal.

Young Men's Christian Association.

SECTION 13.—SOCIAL HYGIENE.

Gold Medal.

Women's Temperance Union.

SECTION 16.—ECONOMIC INTERVENTION OF PUBLIC POWER.

Gold Medals.

Collective Exposition of the States of Northern California, Florida, Illinois, Maine, Michigan, Missouri, New Hampshire, New York, Pennsylvania, and the cities of Buffalo, Cleveland, New York, Philadelphia, Pittsburg, San Francisco, St. Paul, Springfield, Syracuse, Washington.

Carroll Wright. Wells, David.

Silver Medal.

Arthur Hadley, Yale College, Connecticut.

[Continued from SUPPLEMENT, No. 722, page 11540.]

HEREDITY.*

By Sir WILLIAM TURNER.

THE variations which I have spoken of as congenital malformations arise, as a rule, before the time of birth, during the early development of the individual; but there is an important class of cases, in which the evidence for hereditary transmission is more or less strong, which may not exhibit their peculiarities until months, or even years, after the birth of the individual. This class is spoken of as hereditary diseases, and the structural and functional changes which they produce exercise most momentous influences. Sometimes these diseases may occasion changes in the tissues and organs of the body of considerable magnitude, but at other times the alteration is much more subtile, is molecular in its character, requires the microscope for its determination, or is even incapable of being recognized by that instrument.

Had one been discussing the subject of hereditary disease twenty years ago, the first example probably that would have been adduced would have been tuberculosis, but the additions to our knowledge of late years throws some doubt upon its hereditary character. There can, of course, be no question that tubercular disease propagates itself in numerous families from generation to generation, and that such families show a special susceptibility or tendency to this disease in one or other of its forms. But, while fully admitting the predisposition to it which exists in certain families, there is reason to think that the structural disease itself is not hereditarily transmitted, but that it is directly excited in each individual in whom it appears by a process of external infection due to the action of the tubercle bacillus. Still, if the disease itself be not inherited, a particular temperament which renders the constitution liable to be attacked by it is capable of hereditary transmission.

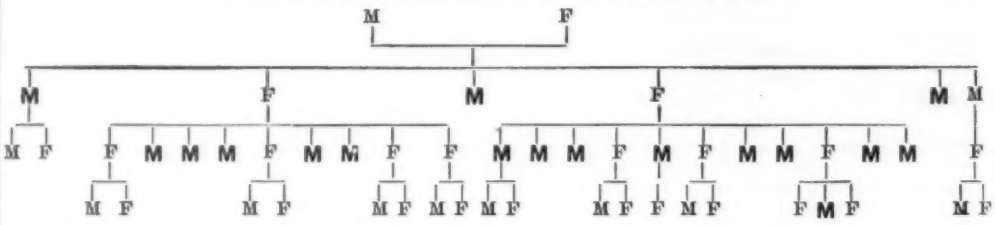
Sir James Paget,† when writing on the subject of cancer, gives statistics to show that about one quarter of the persons affected were aware of the existence of the same disease in other members of their family, and he cites particular instances in which cancer was present in two and even four generations. He had no doubt that the disease can be inherited—not, he says, that, strictly speaking, cancer or cancerous material is transmitted, but a tendency to the production of those conditions which will finally manifest themselves in a cancerous growth. The germ from the cancerous parent must be so far different from the normal as after the lapse of years to engender the cancerous condition.

Heredity is also one of the most powerful factors in the production of those affections which we call gout and rheumatism. Sir Dyce Duckworth, the latest systematic writer on gout, states that in those families whose histories are the most complete and trustworthy the influence is strongly shown, and occurs in from fifty to seventy-five per cent. of the cases; further, that the children of gouty parents show signs of articular gout at an age when they have not assumed those habits of life and peculiarities of diet which are regarded as the exciting causes of the disease.

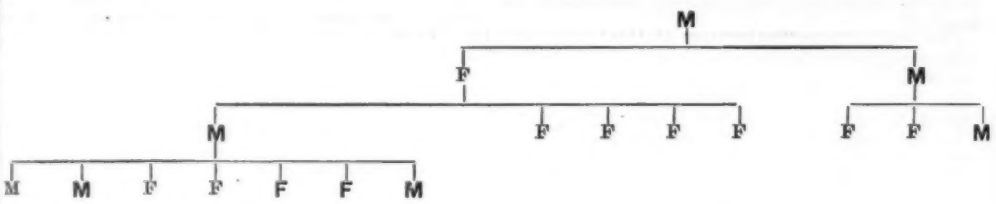
Some interesting and instructive family histories, in which the hereditary transmission of a particular disease through several generations has been worked out, are recorded by Prof. Klebs in his "Allgemeine Pathologie."

I may draw from these one or two additional illustrations. Some families exhibit a remarkable tendency to bleed when the surface of the body is injured or bruised, and the bleeding is stopped with difficulty. The hemorrhagic tendency is not due to the state of the blood, but to a softening or degeneration of the walls of the blood vessels, so that they are easily torn. In one family, the tree of which is here subjoined, this peculiarity showed itself in one generation in three out of four males; in the next generation, in thirteen out of fourteen males; while in the immediately succeeding generation only one out of nine males was affected; so that it would seem as if the tendency was fading away in it. It is remarkable that throughout the series, though the transmission of the affection went through the female members, they themselves remained free from it.

THE BLEEDING FAMILY MAMPEL, RECORDED BY DR. LOSSEN.



Another illustration may be taken from the well-known disease of the eyeball called cataract. Dr. Appenzeller has given an account of a family which exhibited so strong a tendency to this affection that the males were affected in four generations, though the females did not entirely escape, as is shown in the subjoined family tree.



In neither of these families can it be said that the structural lesion itself is transmitted, but that the tendency or predisposition to produce it is inherited. The germ plasm, therefore, in these individuals must have been so modified from the normal as to carry with it certain peculiarities, and to induce the particular form of disease which showed itself in each family.

In connection with the tendency to the transmissibility of either congenital malformations or diseases, consanguinity in the parents, although by no means a constant occurrence, is a factor which in many cases must be taken into consideration.* If we could conceive both parents physiologically perfect, then it may be presumed that the offspring would be so also; but if there be a departure in one parent from the plane of physiological perfection, then it may be safely assumed that either the immediate offspring or a succeeding generation will display a corresponding departure in greater or less degree. Should both parents be physiologically imperfect, we may expect the imperfections if they are of a like nature to be intensified in the children. It is in this respect, therefore, that the risk of consanguineous marriages arises, for no family can lay claim to physiological perfection.

When we speak of tendencies, susceptibilities, proclivities, or predisposition to the transmission of characters, whether they be normal or pathological, we employ terms which undoubtedly have a certain vagueness. We are as yet quite unable to recognize, by observation alone, in the germ-plasm any structural change which would enable us to say that a particular tendency or susceptibility will be manifested in an organism derived from it. We can only determine this by following out the life history of the individual. Still it is not the less true that these terms express a something of the importance of which we are all conscious. So far as man is concerned, the evidence in favor of a tendency to the transmission of both structural and functional modifications which are either of dis-service or positively injurious, or both, is quite as capable of proof as that for the transmission of characters which are likely to be of service. Hence useless as well as useful characters may be selected and transmitted hereditarily.

I have dwelt somewhat at length on the transmissibility of useless characters, for it is an aspect of the subject which more especially presents itself to the notice of the pathologist and physician; and little, if at all, to that of those naturalists whose studies are almost exclusively directed to the examination of organisms in their normal condition. But when we look at man, his diseases form so large a factor in his life that they and the effects which they produce cannot be ignored in the study of his nature.

Much has been said and written during the last few years of the transmission from parents to offspring of characters which have been "acquired" by the parent, so that I cannot altogether omit some reference to this subject. It will conduce to one's clearness of perception of this much discussed question if one defines at the outset in what sense the term "acquired characters" is employed; and it is the more advisable that this should be done, as the expression has not always been used with the same signification. This term may be used in a wide or in a more restricted sense. In its wider meaning it may cover all the characters which make their first appearance in an individual and which are not found in its parents, in whatever way they have arisen:

(1.) Whether their origin be due to such molecular changes in the germ-plasm as may be called spontaneous, leading to such an alteration in its character as may produce a new variation; or,

(2.) Whether their origin be accidental, or due to habits, or to the nature of the surroundings, such as climate, food, etc.

Prof. Weismann has pointed out with great force the necessity of distinguishing between these two kinds of "acquired characters," and he has suggested two terms the employment of which may keep before us how important it is that these different modes of origin should be recognized. Characters which are produced in the germ-plasm itself by natural selection, and all other characters which result from this latter cause, he names *blastogenic*. He further maintains that all blastogenic characters can be transmitted; and in this conclusion, doubtless, most persons will agree with him. On the other hand, he uses the term *somatogenic* to express those characters which first appear in the body itself, and which follow from the reaction of the *soma* under direct external influences. He includes under this head the effects of mutilation, the changes which follow from increased or diminished performance of function, those directly due to nutrition, and any of the other direct external influences which act upon the body. He further maintains that the somatogenic characters are not capable of transmission from parent to offspring, and he suggests that in future discussions on this subject the term "acquired characters" should be restricted to those which are somatogenic.

Thus one might say that blastogenic characters arising in the germ would be acquired in the individual by the action of the germ upon the soma; so that if we return again to the graphic illustration previously employed, the germ plasm represented by the small italic letters *abcd* would act upon the soma represented by the capital letters A, B, C, D. Somatogenic characters, again, arising in the soma, would be acquired by the action of the soma A, B, C, D upon the contained germ plasm *abcd*. But whether those acquired characters expressed by the term somatogenic can or cannot be transmitted has been fruitful of discussion.

That the transmission of characters so acquired can take place is the foundation of the theory of Lamarck, who imagined that the gradual transformation of species was due to a change in the structure of a part of an organism under the influence of new conditions of life, and that such modifications could be transmitted to the offspring. It was also regarded as of importance by Charles Darwin, who stated* that all the changes of corporal structure and mental power cannot be exclusively attributed to the natural selection of such variations as are often called spontaneous, but that great value must be given to the inherited effects of use and disuse, some also to the modification in the direct and prolonged action of changed conditions of life, also to occasional reversions of structure. Herbert Spencer believes† that the natural selection of favorable varieties is not in itself sufficient to account for the whole of organic evolution. He attaches a greater importance than Darwin did to the share of use and disuse in the transmission of variations. He believes that the inheritance of functionally produced modifications of structure takes place universally, and that as the modification of structure by function is a *vera causa* as regards the individual, it is unreasonable to suppose that it leaves no traces in posterity.

On the other hand, there are very eminent authorities who contend that the somatogenic acquired characters are not transmissible from parent to offspring. Mr. Francis Galton, for example, gives a very qualified assent to this proposition. Prof. His, of Leipzig, doubts its validity. Prof. Weismann says that there is no proof of it. Mr. Alfred Russel Wallace, in his most recent work,‡ considers that the direct action of the environment, even if we admit that its

* Opening address by Prof. Sir William Turner, M.B., LL.D., F.R.SS.L. and E., President of Section H, Anthropology. Read before the British Association, Newcastle, 1889.—*Nature*.

† "Lectures on Surgical Pathology," third edition, revised and edited by the author and W. Turner (London, 1870).

* I may especially refer for a discussion of this subject to an admirable essay, by Sir Arthur Mitchell, K.C.B., "On Blood Relationship in Marriage considered in its Influence upon the Offspring."

* Preface to the second edition of "Descent of Man," 1885; also "Origin of Species," first edition.

† "Factors of Organic Evolution," *Nineteenth Century*, 1886.

‡ "Darwinism," p. 443 (London, 1889).

effects on the individual are transmitted by inheritance, are so small in comparison with the amount of spontaneous variation of every part of the organism that they must be quite overshadowed by the latter. Whatever other causes, he says, have been at work, natural selection is supreme to an extent which even Darwin himself hesitated to claim for it.

There is thus a conflict of opinion among the authorities who have given probably the most thought to the consideration of this question. It may appear, therefore, to be both rash and presumptuous on my part to offer an opinion on this subject. I should, indeed, have been slow to do so had I not thought that there were some aspects of the question which seemed not to have been sufficiently considered in its discussion.

In the first place, I would, however, express my agreement with much that has been said by Prof. Weismann on the want of sufficient evidence to justify the statement that a mutilation which has affected a parent can be transmitted to the offspring. It is, I suppose, within the range of knowledge of most of us that children born of parents who have lost an eye, an arm, or a leg, come into the world with the full complement of eyes and limbs. The mutilation of the parent has not affected the offspring; and one would indeed scarcely expect to find that such gross visible losses of parts as take place when a limb is removed by an accident or a surgical operation should be repeated in the offspring. But a similar remark is also applicable to such minor mutilations as scars, the transmission of which to the offspring, though it has been stoutly contended for by some, yet seems not to be supported by sufficiently definite instances.

I should search for illustrations of the transmission of somatogenic characters in the more subtile processes which affect living organisms, rather than those which are produced by violence and accident. I shall take as my example certain facts which are well known to those engaged in the breeding of farm stock or of other animals that are of utility to or are specially cultivated by man.

I do not refer to the influence on the offspring of impressions made on the senses and nervous system of the mother, the first statement of the effects of which we find in the book of Genesis, where Jacob set peeled rods before the flocks in order to influence the color and markings of their young; though I may state that I have heard agriculturists relate instances from their own experience which they regarded as bearing out the view that impressions acting through the mother do influence her offspring. But I refer to what is an axiom with those who breed any particular kind of stock, that to keep the strain pure, there must be no admixture with stock of another blood. For example, if a shorthorned cow has a calf by a Highland sire, that calf, of course, exhibits characters which are those of both its parents. But future calves which the same cow may have when their sires have been of the shorthorned blood may, in addition to shorthorn characters, have others which are not shorthorned, but Highland.

The most noteworthy instance of this transmission of characters acquired from one sire through the same mother to her offspring by other sires is that given in the often quoted experiment by a former Lord Morton.* An Arabian mare in his possession produced a hybrid the sire of which was a quagga, and the young one was marked by the zebra-like stripes. But the same Arabian had subsequently two foals, the sire of which was an Arab horse, and these also showed some zebra-like markings. How, then, did these markings characteristic of a very different animal arise in these foals, both parents of which were Arabians? I can imagine it being said that this was a case of reversion to a very remote striped ancestor, common alike to the horse and the quagga. But, to my mind, no such far-fetched and hypothetical explanation is necessary. The cause of the appearance of the stripes seems to me to be much nearer and more obvious. I believe that the mother had acquired, during her prolonged gestation with the hybrid, the power of transmitting quagga-like characters from it, owing to the interchange of material which had taken place between them in connection with the nutrition of the young one. For it must be kept in mind that in placental mammals an interchange of material takes place in opposite directions, from the young to the mother as well as from the mother to the young.† In this way the germ plasm of the mother, belonging to ova which had not yet matured, had become modified while still lodged in the ovary. This acquired modification had influenced her future offspring, derived from that germ plasm, so that they in their turn, though in a more diluted form, exhibited zebra-like markings. If this explanation be correct, then we have an illustration of the germ plasm having been directly influenced by the soma, and of somatogenic acquired characters having been transmitted.

But there are other facts to show that the isolation of the germ cells or germ plasm from the soma cells is not so universal as might at the first glance be supposed. Weismann himself admits that in the hydroids the germ plasm is present in a very finely divided, and therefore invisible, state, in certain somatic cells in the beginning of embryonic development, and that it is then transmitted through innumerable cell generations to those remote individuals of the colony in which sexual products are formed. The eminent botanist Prof. Sachs states that in the true mosses almost any of the cells of the roots, leaves, and shoot axes may form new shoots and give rise to independent living plants. Plants which produce flowers and fruit may also be raised from the leaves of the *Begonia*. I may also refer to what is more or less familiar to everybody, that the tuber of the potato can give rise to a plant which bears flowers and fruit. Now in all these cases the germ plasm is not collected in a definite receptacle isolated from the soma, but is diffused through the cells of the leaves of the *Begonia* or amid those of the tuber of the potato, and the propagation of the potato may take place through the tuber for several generations without the necessity of having to recur to the fruit for seed. It seems difficult, therefore, to understand why, in such cases, the nutritive processes which affect and modify the soma cells should not also react upon the germ plasm, which, as Weismann admits, is so intimately associated with them.

Those who uphold the view that characters acquired by the soma cannot be transmitted from parents to offspring undoubtedly draw so large a check on the bank of hypothesis that one finds it difficult, if not impossible, to honor it. Let us consider for one moment all that is involved in the acceptance of this theory, and apply it in the first instance to man. On the supposition that all mankind have been derived from common ancestors through the continuity of the germ plasm, and that this plasm has undergone no modification from the *persona* or *soma* of the succession of individuals through whom it has been transmitted, it would follow that the primordial human germ-plasm must have contained within itself an extraordinary potentiality of development—a potentiality so varied that all those multiform variations in physical structure, tendency to disease, temperament, and other characters and dispositions which have been exhibited by all the races and varieties of men who either now inhabit or at any period in the world's history have inhabited the earth, must have been included in it. But if we are to accept the theory of natural selection, as giving a valid explanation of the origin of new species, then the non-transmissibility of somatogenic acquired characters has a much more far-reaching significance. For if all the organisms, whether vegetable, animal, or human, which have lived upon the earth have arisen by a more or less continuous process of evolution from one or even several simple cellular organisms, it will follow, as a logical necessity of the theory, that these simple organisms must have contained in their molecular constitution a potentiality of evolution into higher and more complex forms of life, through the production of variations, without the intermediation of any external force or influence acting directly upon the soma. Further, this must have endured throughout a succession of countless individual forms and species, extending over we know not how many thousands of years, and through the various geological and climatic changes which have affected the globe.

The power of producing these variations would therefore, on this theory, have been from the beginning innate to the germ-plasm, and uninfluenced in any way by its surroundings. Variations would have arisen spontaneously in it, and, for anything that we know, as it were by accident, and without a definite purport or object. But whether such variations would be of service or dis-service could not be ascertained until after their appearance in the soma had subjected them to the test of the conditions of life and the environment.

Let us now glance at the other side of the question. All biologists will, I suppose, accept a proposition that the individual soma is influenced or modified by its environment or surroundings. Now, if on the basis of this proposition the theory be grafted that modifications or variations thus produced are capable of so affecting the germ-plasm of the individual in whom the variation arises as to be transmitted to its offspring —and I have already given cases in point—then such variations might be perpetuated. If the modification is of service, then presumably it will add to the vitability of the individual, and through the interaction between the soma and the germ-plasm, in connection with their nutritive changes, will so affect the latter as to lead to its being transmitted to the offspring. From this point of view the environment would, as it were, determine and regulate the nature of those variations which are to become hereditary, and the possibility of variations arising which are likely to prove useful becomes greater than on the theory that the soma exercises no influence on the germ-plasm. Hence I am unable to accept the proposition that somatogenic characters are not transmitted, and I cannot but think that they form an important factor in the production of hereditary characters.

To reject the influence which the use and disuse of parts may exercise both on the individual and on his offspring is like looking at an object with only a single eye. The morphological aspect of organic structure is undoubtedly of fundamental importance. But it should not be forgotten that tissues and organs, in addition to their subjection to the principles of development and descent, have to discharge certain specific purposes and functions, and that structural modifications arise in them in correlation with the uses to which they are put, so as to adapt them to perform modified duties. It may be difficult to assign the exact value which physiological adaptation can exercise in the perpetuation of variations. If the habit or external condition which has produced a variation continues to be practiced, then, in all probability, the variation would be intensified in successive generations. But should the habit cease or the external condition be changed, then, although the variation might continue to be for a time perpetuated by descent, it would probably become less strongly marked and perhaps ultimately disappear. One could also conceive that the introduction of a new habit or external condition, the effect of which would be to produce a variation in a direction different from that which had originally been acquired, would tend to neutralize the influence of descent in the transmission of the older character.

By accepting the theory that somatogenic characters are transmitted, we obtain a more ready explanation how men belonging to a race living in one climate or part of the globe can adapt themselves to a climate of a different kind. On the theory of the non-transmissibility of these acquired characters, long periods of years would have to elapse before the process of adaptation could be effected. The weaker examples, on this theory, would have had to have died out, and the racial variety would require to have been produced by the selection of variations arising slowly, and requiring one knows not how many hundreds or thousands of years to produce a race which could adapt itself to its new environment. We know, however, that this process of the dying out of the weakest and the selection of the strongest is not necessary to produce a race which possesses well recognizable physical characters. For most of us can, I think, distinguish the nationality of a citizen of the United States by his personal appearance, without being under the necessity of waiting to hear his speech and intonation.

It may perhaps be thought that, in selecting the subject of heredity for my address, and in treating it, as I have to a large extent done, in its general biological aspects, I have infringed upon the province of Section D. But I am not prepared to admit that any such encroachment has been made. Man is a living organism, with a physical structure which discharges a variety of functions, and both structure and functions correspond in many respects, though with characteristic differences, with those which are found in animals. The study of his physical frame cannot therefore be separated from that of other living organisms, and the processes which take place in the one must also be investigated in the other. Hence we require, in the special consideration of the physical framework of man, to give due weight to those general features of structure and functions which he shares in common with other living organisms. But whatever may have been the origin of his frame, whether by evolution from some animal form or otherwise, we can scarcely expect it ever to attain any greater perfection than it at present possesses.

The physical aspect of the question, although of vast importance and interest, yet by no means covers the whole ground of man's nature, for in him we recognize the presence of an element beyond and above his animal framework.

Man is also endowed with a spiritual nature. He possesses a conscious responsibility which enables him to control his animal nature, to exercise a discriminating power over his actions, and which places him on a far higher and altogether different platform than that occupied by the beasts which perish. The kind of evolution which we are to hope and strive for in him is the perfecting of this spiritual nature, so that the standard of the whole human race may be elevated and brought into more harmonious relation with that which is holy and divine.

* Philosophical Transactions, 1831; also Darwin's "Animals and Plants under Domestication," first edition, vol. i. p. 408, 1868.

† See for example, Essays by Profs. Harvey and Gasserow and Mr. Savory; also my "Lectures on the Comparative Anatomy of the Placenta" (Edinburgh, 1876).

WONDERS OF NATURE—THE POETRY OF GEOLOGY.

By T. DE WITT TALMAGE.

THAT valley of the Yosemite is eight miles long and a half mile wide, and three thousand feet deep. It seems as if it had been the meaning of Omnipotence to crowd into as small a place as possible some of the most stupendous scenery of the world. Some of the cliffs you do not stop to measure by feet, for they are literally a mile high. If Jehovah has a throne on earth, these are its white pillars.

No pause for the eye, no stopping place for the mind. Mountains hurled on mountains. Mountains in the wake of mountains. Mountains flanked by mountains. Mountains split. Mountains ground. Mountains fallen. Mountains triumphant. As though Mt. Blanc, and the Adirondacks, and Mount Washington were here uttering themselves in one magnificent chorus of rock, and precipice, and waterfall.

Yonder is Yosemite Falls, dropping 2,634 feet, sixteen times greater descent than that of Niagara. These waters dashed to death on the rocks, so that the white spirit on the slain waters ascending in a robe of mist seeks the heaven. Yonder is Nevada Falls, plunging 700 feet, the water in arrows, the water in rockets, the water in pearls, the water in amethysts, the water in diamonds. That cascade flings down the rocks enough jewels to array all the earth in beauty, and rushes on until it drops into a very hell of waters, the smoke of their torment ascending for ever and ever.

But the most wonderful part of this American continent is the Yellowstone Park. After all poetry has exhausted itself and all the Morans, and Bierstadts, and the other enchanting artists have completed their canvas, there will be other revelations to make and other stories of its beauty and wrath, splendor and agony, to be recited. Yellowstone Park is a geologist's paradise.

In some portions of it there seems to be the anarchy of the elements. Fire and water and the vapor born of that marriage, terrific. Geyser cones or hills of crystal that have been over five thousand years growing. In places the earth, throbbing, sobbing, groaning, quaking with aqueous paroxysm.

At the expiration of every fifty-five minutes one of the geysers tossing its boiling water 185 feet in the air and then descending into swinging rainbows. Caverns of pictured walls large enough for the sepulcher of the human race. Formations of stone in shape and color of calla lilly, of heliotrope, of rose, of cowslip, of sunflower, and of gladiola. Sulphur and arsenic, and oxide of iron, with their delicate pencils, turning the hills into a Luxemburg or a Vatican picture gallery. The so-called Thanatopsis geyser, exquisite as the Bryant poem it was named after, and the so-called Evangeline geyser, lovely as the Longfellow poem it commemorates. The so-called Pulpit terrace, from its white elevation preaching mightier sermons of God than human lips ever uttered. The so-called Bethesda geyser, by the warmth of which invalids have already been cured, the Angel of Health continually stirring the waters. Enraged craters, with heat at five hundred degrees, only a little below the surface.

In some places waters are innocent and smiling as a child making a first attempt to walk from its mother's lap, and not far off as foaming, and frenzied, and ungovernable as a maniac in murderous struggle with his keepers.

But after you have wandered along the geyserite enchantment for days and begin to feel that there can be nothing more of interest to see, you suddenly come upon the peroration of all majesty and grandeur, the Grand canon. It is here that it seems to me—and I speak it with reverence—Jehovah seems to have surpassed Himself. It seems a great gulch let down into the eternities.

Here, hung up, and let down, and spread abroad are all the colors of land, and sea, and sky. Upholstering of the Lord God Almighty. Best work of the Architect of worlds. Sculpturing by the Infinite. Masonry by an omnipotent trowel. Yellow! You never saw yellow unless you saw it there. Red! You never saw red unless you saw it there. Violet! You never saw violet unless you saw it there. Triumphant banners of color. In a cathedral of basalt, sunrise and sunset married by the setting of rainbow ring.

Gothic arches, Corinthian capitals, and Egyptian basilicas built before human architecture was born. Huge fortifications of granite constructed before war forged its first cannon. Gibraltars and Sebastopols that never can be taken. Alhambras where kings of

strength and queens of beauty reigned long before the first earthly crown was impearled. Thrones on which no one but the King of Heaven and Earth ever sat. Font of waters at which the lesser hills are baptized, while the giant cliffs stand round as sponsors.

Hanging over one of the cliffs, I looked off until I could not get my breath, then retreating to a less exposed place, I looked down again. Down there is a pillar of rock that in certain conditions of the atmosphere looks like a pillar of blood. Yonder are fifty feet of emerald on a base of five hundred feet of opal. Wall of chalk resting on pedestals of beryl. Turrets of light tumbling on floors of darkness. The brown brightening into golden. Snow of crystal melting into fire of carbuncle. Flaming red cooling into russet. Cold blue warming into saffron. Dull gray kindling into solferino. Morning twilight flushing midnight shadows. Auroras crouching among rocks.

See all this carnage of color up and down the cliffs; it must have been the battle field of the war of elements. Here are all the colors of the wall of heaven, neither the sapphire nor the chrysolite, nor the topaz, nor the jacinth, nor the amethyst, nor the jasper, nor the twelve gates of twelve pearls wanting.

THE AMINES PROCESS FOR SEWAGE.

A SOMEWHAT remarkable "demonstration" of the merits of a sewage process recently took place at Wimbledon at the sewage works belonging to the local board, which the *Engineer* thus describes. More than two hundred persons assembled on the occasion, including the Lord Mayor and several official personages. Engineers, medical officers of health, and scientific chemists formed a considerable portion of the gathering, together with members of the London County Council and other public bodies. The process to be seen was that invented by Mr. Hugo Wollheim, and now in the hands of a syndicate, of which Mr. Ellice-Clark is the chairman, Mr. Wollheim being the managing director.

The theory on which the process is based is that a sewage effluent can only be regarded as harmless, from the hygienic point of view, when all the bacteria capable of giving rise to disease, "or of inducing chemical change," have been entirely extirpated or destroyed. There is a contrary theory, having many powerful advocates, which teaches that certain bacteria are beneficial in their action on sewage, and that it is desirable they should live.

Mr. Wollheim considers it best to make a clean sweep, and has devised a process which, having been put into operation on a portion of the West Ham sewage, was found by Dr. Klein to have the effect of producing an absolutely sterilized effluent. The mixture employed for this purpose would scarcely seem well adapted for the purification of sewage or for the production of an effluent that could be considered in all respects harmless.

At Wimbledon the average quantity of lime introduced into a gallon of sewage is 47 grains, together with 3 grains of herring brine. Such a dose of lime might be expected to do something, and certainly when we tasted the effluent a short time ago it was rather hot in the mouth. As for the herring brine, this produced a slight odor, which, according to some persons, resembled that of the sea breeze. Others thought it had "an ancient and a fish-like smell." However, all this can be tolerated, provided certain counterbalancing advantages are secured. Of these there was some evidence at the "demonstration."

Milk of lime and herring brine having been mingled with the sewage as it flowed into the works at a depth of several feet below the surface, the liquid thus dosed was pumped by a 16 horse power engine into a conduit along which it flowed toward the settling tanks.

As the sewage emerged into the air, no smell was perceptible. At the same time a sample of the raw sewage was, if we may use the term, somewhat "mild." Flowing on to the farthest tank in a row of six, the treated sewage entered until it filled up the space to a depth of 6 ft. It was expected that in half an hour after the flow was cut off, the suspended matters would all be deposited at the bottom of the tank, leaving a clear liquid above the deposit. In much less than the half hour, the top water began to flow over into the next tank, and had the appearance of being brilliantly clear. Here there was a slight "fishy" odor, about the exact nature of which opinions differed. It was stated by Mr. Ellice-Clark, who cicerone'd the company, that the water could be drawn off and the tank filled again twelve times before the removal of the sludge. In fact, the sludge is to assist in purifying each fresh supply of sewage. For this purpose, when the tank is first filled up, the sewage receives as much as 70 grains of lime per gallon, after which the quantity is reduced to 45 grains, thus making the average of 47 grains. The proportion of herring brine remains the same throughout.

The sludge at the bottom of the tanks is got out by gravitation, flowing down through underground pipes into the press house, the tanks being elevated and embanked. The supernatant water flows all through floating valves, and is conveyed by pipes to the sewage farm close by.

But it is claimed for this process that there is no need either to press the sludge or to filter the effluent through land. The sludge is without odor, and undergoes no putrefactive change. So also the effluent remains permanently good, and is said to be fit to go direct into the river, its composition being such as to meet the requirements set forth some years ago by the Rivers Pollution Commissioners. This statement, however, requires some modification, as it is evident that the effluent, with its burden of lime, requires dilution. Concerning the curious name "Amines," we should explain that this is employed as expressive of the circumstance that the lime acts on certain organic bases belonging to the group of "amines," or ammonia compounds, and which may be derived from various sources, herring brine among the rest. When these organic bases are acted upon by lime, a very soluble gas is evolved, which spreads rapidly through every part of the liquid, and is held in solution therein with great tenacity. This gaseous reagent is termed by Mr. Wollheim "amminol," and is a very powerful disinfectant.

The extraordinary quantity of lime used by Mr. Wollheim naturally lays his process open to criticism. It is admitted that no fish would live in the effluent. But the effluent goes into a river, and is speedily diluted. When mingled with ten times its volume, the effluent ceases to injure the fish. It may naturally be asked where a sufficient supply of herring brine is to be obtained? A reply is given that other sources of amminol are available. As to the economical aspect of the process, the materials are estimated to cost from a halfpenny to three farthings per thousand gallons of sewage, or from £2 10s. to £3 per million gallons. It is contended that this is less than the cost of the chemicals in other processes.

As the sludge is inoffensive, it can be used for raising the level of low-lying lands, thereby avoiding the expense of pressing or of barging out to sea. Mr. Ellice-Clark, in an able address which he delivered in the course of the proceedings, stated that wherever works had been erected suited to the chemical treatment of sewage, there the Amines process could be tried without any additional capital outlay. It having been remarked that the sewage of Wimbledon was not complicated by the intrusion of factory refuse, Mr. Ellice-Clark replied that in February last they treated 160,000 gallons of West Ham sewage, containing refuse from numerous factories and chemical works; and whereas the sewage as tested by Dr. Klein contained enormous quantities of bacteria, in the effluent from the Amines process there was none.

Among the speeches made on the occasion, in addition to the address by Mr. Ellice-Clark, was one by Mr. Townsend, the chairman of the Wimbledon Local Board, expressing his satisfaction at the experiments which had been made with the Amines process. The board were about to have the process more fully tried by their own officials, when they would be able to decide conclusively as to its merits, including the effect of the lime upon grass crops. By the system previously pursued at Wimbledon, combining chemical treatment with sewage farming, they were able to get five or six crops of Italian rye grass in a year.

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